The Yorkshire and Humber
Paediatric Critical Care
Operational Delivery Network

Clinical Guidelines

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These guidelines have been written to support Network clinicians in the stabilisation of critically ill children and in the referral of these children to Paediatric Intensive Care through Embrace.
They are a synthesis of up to date evidence and best practice in the region, and contain elements of previous documents and guidelines used in Yorkshire and Humber.

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SECTION 1

PATIENT PATHWAYS

1.1 Contacting PICU

For children who need access to Paediatric Critical Care facilities please contact Embrace on 0114 268 8180. The call handler will collect enough information to enable them to safely process your call. Depending on your requirements, Embrace will:

- Locate and conference call the relevant specialist(s) you need to give advice on your clinical problem
- Send a transport team when appropriate
- Find a bed for your patient; normally this will follow established referral patterns but if the local units are full Embrace will find the nearest suitable bed

In an emergency situation all three processes will be performed simultaneously.

All calls to Embrace are recorded
Consultants in Leeds and Sheffield are still available for advice or informal discussions at any time and can be reached through Embrace or by ringing the unit directly.

Embrace (Yorkshire & Humber Infant & Children's Transport Service) 0114 268 8180 General enquiries 0114 305 3005
Leeds PICU 0113 392 7447 LGI switchboard 0113 243 2799
Sheffield PICU 0114 271 7119 Sheffield Chidren's Hospital Switchboard 0114 271 7000

If you would prefer to speak to the PICU consultant directly, particularly if you are ringing for advice or wish to discuss a case informally, please make this clear. Your telephone call will either be transferred directly to the consultant, or your call will be returned as soon as possible. We welcome early discussion of cases in which you anticipate the potential need for Intensive Care and would like advice as to the appropriateness of an intervention.

We would suggest that if you are referring a patient to Embrace you use the downloadable (www.embrace.sch.nhs.uk) *"acute call medical control form"* as a template to ensure that you have all the required clinical information available.

1.2 Acute neurosurgical admissions

Time critical neurosurgical cases require one way transfer by referring hospital team to Leeds or Sheffield. There are well established referral pathways into Leeds and Sheffield. You are advised to use Embrace to help you with the referral process. **See Section 5.1** for guidance on non-trauma neurosurgical emergencies. **Refer to the Regional Paediatric Major Trauma Guidelines to support the care of children with severe traumatic brain injury.**

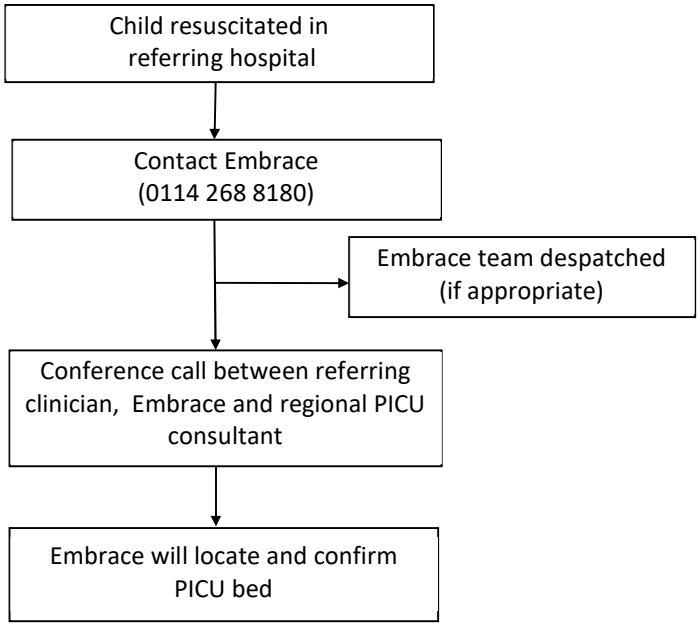
Children who require emergency neurosurgery will **not** be refused, regardless of bed capacity. They will be accepted and then arrangements made for their continuing care after definitive treatment.

Hull does not accept admissions for emergency paediatric neurosurgery.

1.3. Acute medical and surgical admissions

These children will normally be transferred by the Embrace team. The referral pathway is summarised below.

For a more detailed explanation of the transport process see Section 1.8.



1.4 Cardiology referrals

The Cardiologists in Leeds are available to provide advice on management and the need for, and urgency of, transfer at all times. They can either be contacted either directly through Leeds General Infirmary switchboard (0113 243 2799) or through Embrace (0114 268 8180).

If transfer is likely to be required, we suggest that you contact Embrace initially, who will call conference the cardiologist and other appropriate specialists and then organise the bed and transfer with the agreed degree of urgency.

If the call has been made without involving Embrace and the child does require transfer, then you will need to contact Embrace as soon as possible with a record of the advice you have received and a clear understanding as to the urgency of the transfer.

Some children who require emergency cardiology intervention, e.g. Infants with transposition of the great arteries who don't respond to high dose prostin, need to be transferred to Leeds as a matter of urgency. The Leeds service will accept them irrespective of bed capacity, and ***the time critical transfer may need to be performed by the referring hospital team****.*

1.5 Burns referrals

Refer to the Regional Paediatric Major Trauma Guidelines to support the care of children with burns.

Consider the presentation of the child, their injuries and the story (or absence) carefully. Discuss any cases which are concerning or unusual with the on-call Paediatric Consultant.

Refer all children meeting the following criteria to a Burns Unit or Burns Centre for further discussion:

- Age less than 6 months
- Any burn with evidence of non-accidental injury (also refer to the local paediatric team)
- Burn of any thickness to special areas – face, hands, feet, perineum, flexures.
- Any circumferential burn
- Any thickness burn of 2% or more Total Body Surface Area (TBSA)
- Any full thickness burn greater than the size of the patient's fingertip
- Significant inhalational burn
- Chemical, radiation, electrical or friction burn and any cold injury
- Any unwell or febrile child with a burn
- Any child with a suspicion of toxic shock syndrome
- Any burn that has not healed at 14 days

Burns services

- Sheffield Children's Hospital has a Burns Unit and a PICU
- Pinderfields has an Adult Burns Centre and a Children's Burns Unit (with limited paediatric high dependency support)
- LGI has a PICU with plastic surgery on site, but no dedicated burns service
- Manchester has a Children's Burns Centre

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Discuss potential referrals with registrar on call at local burn unit before regional transfer

In the Leeds Children's MTC region burns care is co-ordinated from the Burns Unit at Pinderfields via Plastic Surgery Registrar on 01924 541 716.

In the Sheffield Children's MTC region burns care is co-ordinated from the Burns Unit at Sheffield Children's Hospital (SCH). The Plastic Surgery Registrar on-call should be contacted (Mon-Fri 0800-1600 via SCH on 0114 271 7000 and out of hours via Northern General Hospital on 0114 243 4343.

Patients requiring HDU or PICU level care should be referred via Embrace on 0114 268 8180
www.embrace.sch.nhs.uk

1.6 Refusals to PICU admission

The following operates in respect of children refused admission to PICU.

Refusals to PICU admission

1. Children who are unlikely to benefit from intensive care because their prognosis is so poor as to make admission to PICU inappropriate (RCPCH Making decisions to limit treatment in life-limiting and life-threatening conditions in children: a framework for practice 2015)

2. Children whose clinical condition is such that they can be safely managed within the resources available at the referring hospital

3. When there are no staffed beds available on the PICU

Notes:

1. Embrace operates independently of bed availability and will facilitate advice, transport and bed location

2. Children refused PICU admission remain the responsibility of the referring clinician

1.7 Exception report for children cared for in an adult ICU

An exception report must be completed for any child that has been cared for at a location other than is 'normal' practice to enable a case review to take place. Please refer to Yorkshire and Humber Paediatric Critical care ODN Management of Surge & Escalation Standard Operating Procedure V16.4 https://www.networks.nhs.uk/?attachment=8818&document_type=document&download_document_file=1&document_file=1113

See Appendix 1

1.8 Transport policy and procedures

Embrace is the Yorkshire & Humber Infant & Children's Transport Service

Structure of the transport team

Each transfer is supported by a Consultant with training and skills in critical care transport medicine.

Many of the transfers are performed by competent Specialist Trainees or Advanced Nurse Practitioners working with a specialist Transport Nurse. The staff are allocated on the basis of the information given by the referring hospital and the accuracy of this information is therefore vital. The transport consultants will generally attend if patients are unstable, complicated, or as part of an on-going training programme. Historical data indicates that 40% of Embrace paediatric critical care transports are consultant delivered.

Whilst we make every effort to ensure that teams are not sent out to collect children beyond their experience, clinical situations may change. If difficulties arise during a transfer, the Embrace Consultant and/or the PICU

consultant on call will be contacted for advice and back up. We would also expect that consultants at the referring hospital continue to support the transport team.

Mobilisation

The team is provided to assist with stabilisation and the safe transport of patients and is not a primary resuscitation service. We recognise the difficulties that may be encountered managing a sick child outside of a paediatric critical care area. We therefore aim to have the team mobile within 30 minutes of accepting a referral. However, there may occasionally be unavoidable delays, for example when all the teams are already out on calls.

The management of the patient remains the responsibility of the referring consultant during this period and good communication is essential.

Embrace will not normally undertake time critical transfers, and it is vital that all network hospitals retain a capacity to transfer critically ill children

1.9 Trauma pathways

Following the recent trauma review, the Major Trauma Networks began a phased implementation in April 2012. Paediatric trauma patients are defined as children under the age of 16 years.

Within Yorkshire and Humber there are two Major Paediatric Trauma Centres (PMTC) based on the current Paediatric Critical Care Network footprint.

- Leeds General Infirmary – combined Adult and Paediatric Major Trauma Centre
- Sheffield Children's Hospital – Paediatric Major Trauma Centre

Hull Royal Infirmary is not a Paediatric Major Trauma Centre.

Refer to the Regional Paediatric Major Trauma Guidelines

Primary (scene) transfers

Children with major trauma will be assessed for primary bypass to the nearest PMTC if the travel time is less than 60 minutes. Those requiring emergency management of an airway or breathing problem will be transferred to the nearest Trauma Unit (TU).

This primary transfer is the responsibility of the local Ambulance Trust who will communicate directly with relevant receiving hospital.

Secondary (inter-facility) transfers

Those children with major trauma presenting directly to a Trauma Unit and those who are transferred to a Trauma Unit after assessment by the ambulance service will need a secondary ambulance transfer to a Paediatric Major Trauma Centre after initial stabilisation. Paediatric Major Trauma Centres are responsible for the care of all children with major trauma in their Network area. They will accept all children who trigger the pathway for major trauma irrespective of potential outcome or capacity on a 'send and call' basis. Referrals made via Embrace will be connected immediately to the PMTC Emergency Department.

SECTION 2

PREPARING THE CHILD FOR TRANSFER

Note:

Information provided on use of drugs and recommended doses reflect the current practices on the PICUs. Some of these drugs are either not licensed in children, or not licensed for the indication described.

Responsibility for using these drugs rests with the prescriber. Further information may be obtained from the British National Formulary for Children (BNFc) or your hospital pharmacist.

2.1. Procedures at the referring hospital

Once the patient has been accepted for transfer it is important to start preparations for the transfer. See "Preparing a Paediatric Patient for Emergency Transfer" at www.sheffieldchildrens.nhs.uk/embrace for a checklist to support this process.

On arrival at the referring hospital and once handover has been completed, the Embrace team will assume joint responsibility for the management of the patient with the referring clinician. The principal aim of the team is completing the preparation of the child for transport. This may occasionally take some time. It is important that the child is not transferred until adequate stability, vascular access and monitoring have been achieved. In rare cases where a child cannot be suitably stabilised, transfer may not be possible.

These procedures are summarised below:

ACCEPT model	
Assessment –	Handover
	What has been done?
	What needs to be done?
Control -	Team leader to delegate required tasks
Communication -	Professionals
	Parents
	Documentation
Evaluation -	Is transfer still appropriate?
Preparation -	ABC approach
Packaging	
Pre-departure checks	
Transportation	

2.1.1. Drug Infusions

Go to www.sheffieldchildrens.nhs.uk/embrace to access a copy of the Embrace Drug Prescription Card. An adequate prescription **and** syringe label must include:

- The patient's name, the weight on which calculations are based and one other identifier (DoB or Unit no. or NHS no.)
- The mass (and batch number) of the drug to be administered *e.g. 15mg dopamine*
- The total volume of the syringe, (batch number) and nature of the dilutent *e.g. made up to 50ml in 0.9% sodium chloride*
- The rate (or range of rates) of administration *e.g. 5 to 10 microgram/kg/min*
- Signature, date and time

Syringes that are not prescribed and labelled to this standard will be changed

and this will delay transfer

2.2 Stabilisation and safe transfer

Wherever possible, children should be stable, have adequate venous access and appropriate monitoring before transfer. Our guidelines are as follows and apply except in time critical transfer when a compromise may be required between speed and full stabilisation:

Airway

- Airway protected by intubation in most cases
- Place a cuffed endrotrachel tube (except in neonates)
- ETT securely fixed
- ETT position confirmed on CXR

Ventilation

- Appropriate analgesia, sedation and muscle relaxation
- Established on transport ventilator
- Adequate gas exchange confirmed by blood gas analysis. Normally:
    - PaO_2 > 10 kPa unless cyanotic heart disease
    - $PaCO_2$ within acceptable limits for clinical situation

Circulation

- Heart rate, BP stable
- Base excess better than -5 or improving
- Any obvious blood loss controlled
- Haemoglobin more 80 g/L
- Minimum of two routes of appropriately sized venous access
- Arterial line and central venous access are desirable in patients requiring inotropic/vasopressor support
- Central venous access is preferable in those patients who require inotropic / vasopressor support however the use of IO access or peripheral solutions may be appropriate

Neurology

- Seizures controlled, metabolic causes excluded
- Raised intracranial pressure appropriately managed:
    - Positioned head up 20 – 30^o
    - $PaCO_2$ 4.5 - 5.0kPa
    - PaO_2 > 12kPa
    - Consideration given to mannitol or hypertonic saline (sodium chloride 2.7% or 3%)
- Pupillary responses monitored and recorded regularly

Metabolic

- Blood glucose > 4 mmol / l
- Potassium >3mmol/l and < 6 mmol / l
- Ionised calcium > 1 mmol / l or improving with treatment; hypocalcaemia can be a problem in sepsis and is a cause of failure to respond to inotropes

Trauma

- Full primary and secondary survey confirmed complete including trauma series X-rays
- Appropriate spinal immobilisation
- Pneumothoraces drained
- Intra-abdominal injuries adequately investigated and appropriately managed
- Long bone/pelvic fractures stabilised
- Blood available
- Access major haemorrhage protocol

Monitoring

- ECG
- Blood pressure – invasive if cardiovascular instability
- Oxygen saturation
- End tidal pCO_2 (also acts as ventilator disconnection alarm)
- Temperature – Some children will require therapeutic cooling, do not actively re-warm children with raised ICP, post-cardiac arrest or severe cardiovascular instability without discussion.

Don't forget

- Photocopies of notes and drug kardex
- Transfer of radiology by PACS (unless image sharing available)
- Maternal blood sample when appropriate in children < 3 months of age
- Blood products if required, appropriately packaged with paperwork

Care of relatives

Prior to departure the Embrace team update the parents/carers on the condition of their child. Embrace aim to take one parent/carer in the ambulance, but this may not be possible and the decision remains at the discretion of the team. Maps and detailed explanations on how to find the PICU will be provided. Parents/carers not travelling in the ambulance are recommended to either wait 10-15 minutes after the transfer team has departed before following on at a safe pace **or** go home to make arrangements for a stay on PICU (see other children, get fresh clothes and toiletries etc). Preferably a friend or other family member should drive. In some situations a taxi may need to be arranged by the referring hospital.
It is imperative that:

- Parents do not leave for the destination hospital before the transfer team in case of a sudden deterioration in the condition of their child
- Parents do not follow or 'chase' the ambulance
- Contact numbers are obtained from all parents

Parent feedback forms are available at www.sheffieldchildrens.nhs.uk/embrace

2.3. Endotracheal intubation

Whenever possible, endotracheal intubation should be an elective procedure, anticipating and preventing further deterioration in respiratory function. It is best performed by someone experienced in both the procedure and the use of appropriate anaesthetic / sedative agents.

Staff at the referring hospital SHOULD NOT wait for the Embrace team to arrive if intubation and ventilation is indicated. Where necessary, they should seek senior anaesthetic support.

Indications

- Airway obstruction
- Airway protection – actual or potential due to compromised neurological function
- To enable positive pressure ventilation – increased work of breathing, acute respiratory failure, chest trauma, inadequate respiratory muscle function, raised intracranial pressure, shock etc.

Intubation checklist

See www.sheffieldchildrens.nhs.uk/embrace for an example of an intubation checklist to support this process and the Embrace Drug Prescription Card to assist in correctly sizing an endotracheal tube for size and length.

Endotracheal tubes are not usually cut precisely to length but left with 2 - 3cm beyond the lips or nose to allow for fixation, later adjustment and some flexibility if the child moves his/her head. The lengths quoted are those measured at the lips or the nose.

These tables are only a guide. It is important to avoid endobronchial intubation by ensuring that the ETT is not passed too far through the cords. A useful guide is that the tube should be passed through the cords a distance in cm equivalent to and no more than its internal diameter in mm.

Size of ETT	Distance through the cords
3.0 & 3.5 mm	3.0 cm
4.0 & 4.5 mm	4.0 cm
5.0 mm	5.0 cm

A tube that is too short may result in an excessive leak and increases the risk of accidental extubation.

Once intubated a chest X-ray should be performed to confirm correct ETT placement - the tip of the ETT should be at the body of the 2nd thoracic vertebra.

Cuffed endotracheal tubes

Cuffed endotracheal tubes are recommended in infants and children, particularly since the 2020 CoV-19 pandemic. (Uncuffed endotracheal tubes may be placed in neonates.)

- ETT size guide: age/4 +4 in toddlers and children, and 4mm in older infants, in young infants >3 kg 3.5mm, and <3kg 3.0mm
- For infants with lung disease, a tube of adequate size that prevents a leak is key to maintaining PEEP to ensure adequate oxygenation
- There should ideally be an audible leak present before the cuff is inflated
- If the tube does not pass/was placed with difficulty and is a tight fit, replace with 0.5mm smaller size tube
- When the cuff is inflated, a pressure manometer **must** be used to ensure safe cuff pressures (limit pressure according to the manufacturer's recommendations, usually <20cm H_2O
- Care must be taken to ensure that
    - The cuff is fully though the cords
    - The tip of the tube on X-ray is above the carina.

Method

Awake intubations are almost never indicated.

In the acute situation rapid sequence induction is usually the method of choice. Typical drug doses are as shown.

Drug	Dosage	Administration
Propofol	1 – 2 mg/kg	IV
Ketamine	1 - 2 mg/kg IV (or 5 – 10mg/kg IM)	IV or IM
Thiopentone	1- 5 mg/kg	IV
Atracurium	0.5 – 1.0 mg / kg	IV
Rocuronium	0.6 - 0.9 mg/kg	IV
Atropine	20 micrograms / kg (minimum effective dose 100 micrograms, maximum dose 600 micrograms)	IV
Sodium chloride 0.9%	Flush	IV

The performance of rapid sequence induction using these drugs requires an understanding of their pharmacology and in particular the contraindications to their use. It is recommended that this is not attempted by personnel without the appropriate training.

In the shocked child:

- Titrate induction doses carefully, using the minimum effective dose
- Consider ketamine
- Ensure fluid resuscitation before intubation if possible
- Have fluid boluses (10mls/kg aliquots) and adrenaline prepared in appropriate doses

Potential contraindications to rapid sequence induction

- Anticipated difficult intubation e.g. congenital or acquired airway abnormalities
- Upper airway obstruction (e.g. epiglottitis)

Recommended procedure for intubation

Orotracheal intubation is performed in the first instance to secure the airway. Oral tubes may be changed to nasal if:

- There are no contraindications e.g. basal skull fracture / coagulopathy
- Staff feel confident in their abilities to complete the change safely

Preparation

- Check equipment and drugs as above
- Ensure secure venous access
- Monitor ECG and oxygen saturation
- Do not forget C-spine control in cases of trauma

Procedure (additional steps and precautions to be taken if a highly infectious disease agent is suspected e.g. CoV-19)

- Pre-oxygenate, for 3 minutes, with 100% oxygen via a high flow breathing system
- Administer anaesthetic
- Apply cricoid pressure if indicated
- Intubate orally initially
- **If endotracheal intubation is not achieved in 30 seconds discontinue the attempt, ventilate and oxygenate by bag and mask and try again**
- Give boluses of sedation and non-depolarising muscle relaxant (e.g. midazolam and atracurium respectively) once oral intubation has been accomplished
- Ventilate with 100% oxygen and confirm position of the ET tube (ETT) by:
    - Visualising the tube passing through the vocal cords at the time of intubation
    - End tidal carbon dioxide monitoring
    - Watching chest movement
    - Auscultation of the chest (axillae) and stomach
- Secure the ET tube, suction secretions (oropharyngeal and endotracheal), connect to ventilator and ventilate the patient with oxygen
- Pass a gastric tube
- Perform a chest X-ray to confirm correct ETT placement - the tip of the ETT should lay at T2
- Measure blood gases to verify correct ventilator settings after approximately 30 minutes**.**
- A combination of capillary gas and a good SpO_2 trace will suffice in children without cardiovascular compromise.

Failed intubation

If you are unable to visualise the cords or pass an ETT easily, do not make repeated attempts at intubation - it will only result in hypoxia. Stop and call for anaesthetic help.

- Administer 100% oxygen and continue to ventilate via bag and mask until spontaneous respiration returns
- A laryngeal mask airway may be considered if you are having difficulty with bag and mask ventilation and/or continued ventilation is imperative.

Oral vs nasal

Oral tubes are easier and quicker to site and are the route of choice to secure the airway. An oral tube can be exchanged for a nasal once the patient has been stabilised if there are no contra-indications. It is acceptable to manage patients exclusively with an oral tube.

Dealing with leaks

Although anaesthetists are taught to ensure that there is always a leak around a paediatric ET tube, it is not something that we worry about too much in PICU - if the tube has passed through the cords with minimal force we tend to leave it alone, even if there is no leak (except when a cuffed tube is being placed, in this instance there must be a leak before the cuff is inflated).

Sometimes the tube has a substantial leak which interferes with ventilation. Do not pack the pharynx (except as a very temporary measure – see below). Increase the inspiratory pressure and see if you can cope with the leak – can you get adequate gas exchange and not have the ventilator alarm constantly?

If you cannot get the ventilator to cope with the leak, or there are infection control concerns, then either increase the size of the tube or consider placing a cuffed tube of the same size. If using a cuffed tube, don't inflate the cuff initially. Reassess the situation and see if you can ventilate adequately with a deflated cuff.

Sometimes it is difficult to get adequate alveolar recruitment because of the size of the leak and changing the tube is a worrying prospect because of low saturations. In this situation applying cricoid pressure, or temporarily packing the pharynx, can reduce the leak for long enough to allow some more alveolar recruitment, improve the SpO_2 and give you some "breathing space". **Children should not be transferred with a pack in situ.**

Fixation

There are lots of ways of doing this. We use a "double trouser leg" modified Melbourne strapping technique using 1" elastoplast. The crucial part of the technique is to ensure that ETT tube is against the "crotch" of the trouser leg before the leg is wrapped around in order to ensure firm anchoring.

2.4. Ventilation

Circuits

Humidification

It is important that all patients on a ventilator receive humidification to prevent drying of secretions, and damage to the small airways at the cellular level. This can be achieved with a wet humidified circuit OR a Heat and Moisture Exchanger (HME). The use of HMEs at the patient end with a wet circuit is contraindicated. To protect the ventilator from infection these patients should have a bacterial filter at the ventilator end. All patients who are on dry circuits must have a HME close to their airway. To avoid dead space issues these must be correctly sized according to the circuit used and the patients' weight.

Compliance

Circuits need to have a low compliance. Too compliant a circuit will result in loss of tidal volume. This is less of a problem with pressure controlled ventilators than with volume controlled ones. In modern ventilators compliant or large volume tubing can reduce the sensitivity of trigger mechanisms.

Dead space

Apparatus dead space must be minimised. Of particular concern are items such as catheter mounts, HME/bacterial filters and CO_2 sampling cuvettes. The smaller the child, the greater the concern. Some anaesthetic machines are unsuitable for ventilating small children if the side-stream gas sampling device is used.

Ventilator requirements

Time cycled / pressure controlled

In an emergency, children of all sizes can be ventilated on any time cycled, pressure controlled ventilator which can deliver rates up to 50 bpm.

Volume measurement

Ideally the ventilator should be able to measure inspired and expired tidal volume. Some ventilators are not sufficiently sensitive to measure tidal volumes below 50 ml and tidal volume alarms may need to be disabled to ventilate infants.

Initial settings

Pressure

Normal compliance

Adults and children all have similar pressure requirements for ventilation. A child with normal lungs and normal body shape will achieve a normal tidal volume at a ventilator pressure in the range 14 - 18 cmH_2O. The presence of significant leaks will increase the pressure required to achieve adequate tidal volumes and will need to be taken into account in your initial settings.

Tidal volumes per Kg are also similar to adults, with a target range of 6 - 8 ml/kg, which usually equates to a "normal looking" degree of chest excursion. Tidal volumes above 10 ml/kg should be avoided.

Abnormal compliance

In PICU we are not usually concerned about inspiratory pressure up to around 24 cmH_2O. Pressures of 24-28 signify significant lung disease and above 30 we are concerned about the potential for emphysematous change and barotrauma. If such pressures persist for more than a few hours despite steps to improve compliance and the use of permissive hypercapnia we may consider high frequency oscillatory ventilation.

Use of PEEP

Children are always ventilated with PEEP. We use a starting pressure of 4 - 6 cmH_2O and go up to pressures of 10 - 15 cmH_2O if necessary.

Rate

Usual starting rates are as follows:

- Neonates – 30 - 40 bpm
- Infants - 30 bpm
- 1 to 10 yrs - 20 bpm
- 10+ yrs 10 - 20 bpm

In general on PICU we use longer inspiratory (I) times than neonatal units, with an I time of 0.5 to 1.0 sec in most situations. Shorter I times tend to produce progressive atelectasis in infants with respiratory failure outside of the neonatal period.

Initial adjustment/titration

When establishing a child on ventilation, particularly if the ventilator does not have tidal volume measurement, it is important to watch the degree of chest excursion achieved. "Normal" chest excursion is a matter of judgement: a child should have a degree of chest expansion during IPPV similar to that achieved during spontaneous breathing. At any pressure setting this will depend not only on compliance, but also on the degree of leak around the ET tube. Ideally set a "best guess" pressure, look at chest excursion, measure the tidal volume if possible (this should be 6-8 ml/kg), check $EtCO_2$ and adjust the ventilator in response until

you have achieved normal-looking chest movement/tidal volume. Then adjust the rate to achieve the desired CO_2.

Monitoring

SpO_2

Continuous SpO_2 monitoring with appropriate alarms is mandatory for any ventilated child. Running SpO_2 at 92-95% in children ventilated for respiratory failure allows staff to respond appropriately to improvements in the child's condition.

$EtCO_2$

Side-stream CO_2 monitoring is mandatory in a transport situation and should be used whenever an infant or child is intubated. However, you must consider apparatus dead space when using in small children. Remember that a large leak will produce abnormally low $EtCO_2$ readings.

Blood gases

Although arterial catheters are often used, the technical difficulties of inserting them means that many children ventilated for respiratory failure are often managed without them.
When there is no arterial catheter, venous or capillary gases are used. Particular attention needs to be paid to technique when sampling capillary gases in order to obtain valid results. PaO_2 is meaningless in venous or capillary gases, normal pCO_2 is approximately 0.5 kPa higher and pH is slightly lower than an arterial sample.

Adjustment of ventilator settings

When considering targets for CO_2 and O_2 the child's pre-existing state needs to be considered. Some PICU children are chronically hypoxic and/or hypercarbic (chronic lung disease, hypoventilation due to neuromuscular disease or cyanotic congenital heart disease). Parents often know the child's normal saturation and during an intercurrent illness it is pointless to aim higher. The degree of chronic CO_2 retention may often be inferred from the pH and bicarbonate levels on the first blood gas.

Children may be more tolerant of permissive hypoxia and hypercarbia than adults. In children ventilated for respiratory failure, we often choose to allow CO_2 to rise to 8-10 kPa provided that the pH remains above 7.25. We also allow O_2 saturations to fall to 90% if the child is proving hard to ventilate rather than increase inflation pressures above 28-30 cmH_2O and/or FiO_2 above 0.8.

Oxygenation

In general, although SpO_2 can be improved by increasing FiO_2, this does not address the underlying pathological problem causing the shunt. If SpO_2 has fallen below 90%, then FiO_2 needs to be increased to avoid any risk of hypoxic injury. Steps then need to be taken to improve V/Q matching:

- Consider suction/physiotherapy
- Increase PEEP
- Increase Ti
- Increase PiP (avoid Vt > 10ml/kg)

Once the above steps have been taken adjust FiO_2 to maintain SpO_2 92-95%.

Ventilation (CO_2)

In any situation minute volume (MV) depends on a complex set of interactions between the patient's lung compliance, tube leak and ventilator settings. In addition, the degree of lung recruitment – and hence oxygenation - depends, in part, on the peak inspiratory pressure. The appropriate response to any change in CO_2 level depends on the adequacy of oxygenation.

Hyperventilation (low $PaCO_2$)

If oxygenation is adequate (usually SpO_2>92% at FiO_2 < 0.4), it is reasonable to reduce peak inspiratory pressure (PiP) to reduce MV.

If oxygenation remains problematic and tidal volume is less than 10ml/kg, MV should be reduced by reducing the respiratory rate.

Hypoventilation (high $PaCO_2$)

Before adjusting ventilator settings in response to a rise in $PaCO_2$ it is useful to run through a checklist to ensure that tube or patient factors are not primarily responsible.

- Is the tube obstructed (kinked or partially blocked with secretions)?
- Has the size of the leak changed?
    - Has the tip moved proximally, increasing the leak?
- Has the tip moved distally to impinge on the carina or migrated down the right main bronchus (RMB)?
- Is the patient fighting the ventilator?
- Is there equal chest movement and air entry?
    - Has the tube migrated into the right main bronchus?
    - Are there secretions blocking the airway that can be removed by suction ± physiotherapy?
    - Is there a pneumothorax?
    - Is there excessive apparatus dead space?

Once these factors have been excluded, you need to consider if there are non-pulmonary problems which mandate a normal $PaCO_2$ e.g. raised ICP or management of pulmonary vascular resistance in children with heart disease. If not, consider whether any change in ventilator settings is appropriate.

Does the child normally have an elevated $PaCO_2$, and if so, are the current values significantly higher than normal? Are your ventilator pressures already high, and if so, should you consider allowing permissive hypercarbia?

Again, the response depends on oxygenation.
- If oxygenation and lung recruitment are adequate increase the respiratory rate initially.
- If oxygenation is problematic and Vt is less than 8ml/kg increase the PiP initially.

2.5. Sedation, analgesia and muscle relaxation

Sedation and analgesia

Critically ill children who require intubation and ventilation for transfer will be sedated and muscle relaxed to ensure patient comfort and improve endotracheal tube security.

Comfort encompasses a number of areas of different importance to each child:

- Tolerance of endotracheal intubation, assisted ventilation, invasive catheters, etc.
- Analgesia (painful wounds, limbs, viscera)
- Loss of awareness of a frightening environment
- Amnesia for unpleasant procedures
- Maintenance of ‘natural’ sleep patterns

Excessive use of sedative and analgesic agents may result in:

- Haemodynamic instability

- Prolonged need for IPPV / intubation
- Gastrointestinal tract stasis
- Potential immune suppression
- Potential organ toxicity
- Difficulty in assessing neurological state

Sedation levels should be titrated to the lowest level compatible with patient comfort and the security of tubes and invasive lines.

Sedation of muscle relaxed patients

Assessment of the level of sedation in muscle relaxed patients is difficult. Physiological parameters such as heart rate and blood pressure, particularly in response to procedures such as suctioning etc. should be used as a guide. The minimum level of sedation necessary to produce a physiologically unstressed patient is appropriate.

Sedative regimens during stabilisation and transport

- Midazolam and morphine are suitable for most patients.

- Midazolam and fentanyl or alfentanyl are alternative combinations, particularly in the haemodynamically unstable patient.

Always give a bolus (titrated to effect) before commencing an infusion, to ensure effective therapeutic levels.

Propofol

Following advice from the Medicines Control Agency (MCA) propofol should no longer be used for sedation of children on intensive care.

Propofol can be used in all ages for induction and maintenance of anaesthesia and is a reasonable choice for transfer in some circumstances.

Muscle relaxation

The use of muscle relaxation is recommended in the following situations:

- For endotracheal intubation

- During the stabilisation of critically ill children prior to transfer, particularly to help facilitate procedures such as central line insertion

- In the management of patients with extreme cardiovascular and / or respiratory insufficiency where the balance between oxygen delivery and oxygen consumption may be improved by preventing muscle activity

- To prevent rises in intracranial pressure (associated with coughing etc.) in patients with brain injury or cerebral oedema

- To facilitate the safe transfer of some intubated / ventilated patients depending on clinical assessment

Ensure the patient has adequate sedation/analgesia before muscle relaxation.

2.6 Fluid management

Please refer to NICE Guidance

The fluid management in individual children will depend on the clinical circumstances prevailing at the time. It is difficult therefore, to give clear guidelines covering all possible scenarios but the following general principles may be applied.

Aims:

- To provide normal maintenance requirements
- To replace pre-existing deficits and on-going fluid losses
- To prevent hypovolaemia
- To maintain normoglycaemia and normal electrolyte balance

Maintenance fluids:

Calculate routine maintenance IV fluid rates for term neonates according to their age, using the following as a guide:

- From birth to day 1: 50–60 ml/kg/day
- Day 2: 70-80 ml/kg/day
- Day 3: 80–100 ml/kg/day
- Day 4: 100–120 ml/kg/day
- Day 5-28: 120-150ml/kg/day

If term neonates aged 8 days or over need IV fluids for routine maintenance, initially use isotonic crystalloids that contain sodium in the range 131 to 154 mmol/litre with 5% to 10% glucose. For term neonates aged up to 7 days, use professional judgement, taking into account:

- the individual circumstances **and**
- for term neonates in the first days of life, that a sodium content of 131 to 154 mmol/litre may be too high (or sodium may not be needed), and a glucose content of 5% to 10% may be too low.

For term neonates in critical postnatal adaptation phase (for example, term neonates with respiratory distress syndrome, meconium aspiration, hypoxic ischaemic encephalopathy), give no or minimal sodium until postnatal diuresis with weight loss occurs.

Calculate routine maintenance IV fluid rates for children and young people using the Holliday–Segar formula:

Either	Or
100 ml / kg / day for the 1st 10 kg	4 ml/kg/hr for 1st 10 kg
50 ml / kg / day for the 2nd 10 kg	2 ml/kg/hr for 2nd 10 kg
20 ml / kg / day for additional kg	1 ml/kg/hr for additional kg

Be aware that over a 24-hour period, males rarely need more than 2,500 ml and females rarely need more than 2,000 ml of fluids.

If children and young people need IV fluids for routine maintenance, initially use isotonic crystalloids that contain sodium in the range 131–154 mmol/litre.

If there is a risk of water retention associated with non-osmotic antidiuretic hormone (ADH) secretion, consider either:

- restricting fluids to 50–80% of routine maintenance needs **or**
- reducing fluids, calculated on the basis of insensible losses within the range 300–400 ml/m^2/24 hours plus urinary output.

Fluid volume required **to replace pre-existing losses** may be calculated as follows:

Volume = weight (kg) x 1000 ml x % dehydration / 100

This should be given as sodium chloride 0.9% ± potassium infused over 24 - 48 hours over and above normal maintenance described above. Monitor urea and electrolytes (especially potassium) frequently.

Continuing losses, for example gastric contents from NG tubes should be replaced ml for ml with sodium chloride 0.9% (± potassium chloride).

Fluid resuscitation for shock

Hypotension and reduced conscious level implies severe hypovolaemia. Restoration of the circulating volume is a priority.

- Give 10ml/kg boluses over less than 10 minutes of glucose-free balanced isotonic crystalloids as first choice (sodium in the range 131-154 mmol/litre), namely, Plasma-Lyte 148 or Hartmann's solution. 0.9% sodium chloride is an acceptable alternative
- Reassess (pulse rate and character, blood pressure, capillary refill, urine output) and repeat frequently
- In trauma, initial boluses should be 10mls/kg of blood
- Volumes in excess of 100 ml/kg may be required in sepsis; in these circumstances significant haemodilution (and/or dilutional coagulopathy) are likely to occur
- Check haemoglobin and clotting screen and consider the need for transfusion of blood components following the first 40ml/kg
- When volumes in excess of 40 - 60 ml/kg are required, the use of inotropes and ventilatory support and discussion with PICU should also be considered
- The use of sodium chloride 0.9% in large volumes will result in a hyperchloraemic acidosis and an increased base deficit; further fluid management should not be guided by the pH or the base deficit in isolation
- If shock is due to blood loss, use blood early (O negative if necessary), keep crystalloids to a minimum 20ml/kg. Consider transfusing blood components early includingFresh Frozen Plasma and Platelets according to your local major transfusion protocol. Aim to improve coagulation, give tranexamic acid early.

2.7 Inotropes and other vasoactive drugs

See the Embrace Drug Prescription Card at www.sheffieldchildrens.nhs.uk/embrace
for information on making up infusions.

Indications

- Inotropes and other vasoactive drugs are indicated in any circumstance where cardiovascular insufficiency (e.g. poor tissue perfusion, hypotension) persists despite initial resuscitation
- Inotropes and other vasoactive drugs should be considered in any situation where 40ml/kg or more has been given during resuscitation

Notes on the use of inotropes and other vasoactive drugs

- Ensure adequate preload before commencing inotropes or other agents
- Give fluid boluses of 10 mls/kg alliquots as required
- If, despite 40 mls/kg, there is continuing evidence of low cardiac output and poor tissue perfusion (reduced precordial impulse, cold peripheries, slow capillary refill time), then consider inotropes or other vasoactive drug
- The following drugs should be considered:
    - Adrenaline
    - Noradrenaline
    - Dobutamine (may be used if adrenaline/ noradrenaline are not available)
    - Dopamine (may be used if adrenaline/ noradrenaline are not available)
    - Hydrocortisone (bolus dosing)
    - Milrinone
    - Vasopressin
- The choice of agent is based on the pathology rather than 'routine' practice
- Administer via a central line if possible
- All inotropes can be administered via an IO line
- Dilute Adrenaline, Noradrenaline, (Dopamine, Dobutamine), and standard strength Milrinone can be administered via a peripheral line
- **DO NOT DELAY** inotropes and vasoactive agents – use the line you have
- All inotropes and vasoactive agents can be run on a single lumen
- Use a 3-way or 4-way extension on the 'inotrope lumen' so other agents can be added; this keeps lumens free for other infusions
- **Do not** use a filter on these lines
- On multi-lumen lines use the proximal or middle lumen
- If struggling for access, you can infuse inotropes and vasoactive agents with maintenance fluid/sedation
    - this will only be in exceptional circumstances;
    - you will need to be vigilant with the BP
    - you **cannot** bolus your sedation
- For infusion rates of **less than 1ml/hr use a 20ml luerlock syringe**; make up the infusion as normal in a 50ml syringe and decant into the smaller syringe, clearly labelling the total concentration
- If the total infusion rate on the inotrope lumen is less than 1ml/h then run a compatible flush to keep the total rate at 1ml/h

  i.e. adrenaline @ 0.6ml/h with 0.9% sodium chloride or dextrose flush @ 0.4ml/h; in prems with a low hourly fluid total this flush may need to be maintenance
- **Never** bolus inotropes
- **Never** stop inotropes unless the infusion is no longer required; once stopped the line must either be bled back and then flushed, or flushed at the same rate as the original infusion

SECTION 3

TIME CRITICAL TRANSFERS (NON TRAUMA)

Note:

Information provided on use of drugs and recommended doses reflect the current practices on the PICUs. Some of these drugs are either not licensed in children, or not licensed for the indication described.

Responsibility for using these drugs rests with the prescriber. Further information may be obtained from the British National Formulary for Children (BNFc) or your hospital pharmacist.

3.1 Neurosurgical transfers (non-trauma)

Refer to the regional Paediatric Trauma Guidelines to support the care of children with traumatic brain injury.

Additional supportive information and documentation is provided in the regional Safe Transport of Paediatric Patients (STOPP) tool found at www.sheffieldchildrens.nhs.uk/embrace

Key messages:

- CT scan should be done within 30 minutes of the suspicion of a mass lesion
- Delay in transfer to a neurosurgical centre risks serious brain injury or death **but** secondary brain injury must be avoided
- Identify and treat life threatening haemorrhage
- Transfer for emergency neurosurgery should normally be provided by the referring hospital team **NOT** Embrace
- Departure to neurosurgical centre should occur within 60 minutes of completing CT scan
- Acceptance by the regional neurosurgical centre is **NOT** bed dependent
- Transfer of patients who do not require immediate time critical neurosurgery will be carried out by Embrace if they are able to mobilise within 60 minutes of the referral call

Communication:

- **Contact neurosurgeons via Embrace on 0114 268 8180**
- State clearly that the patient requires a neurosurgical transfer and use **SBAR**
- Resuscitation, stabilisation and preparation for transfer should continue in parallel to the referral call
- The Leeds neurosurgical team have requested that their online referral form is also completed; identify a team member to do this and ensure that it does not delay the transfer http://leedsneurosurgery.com/refer/acute/index.html

Responsibilities of paediatric team:

- Consultant paediatrician should be present
- Start resuscitation and inform anaesthetic team immediately
- Arrange emergency CT scan
- Refer to neurosurgeons via Embrace
- Call for a 999 ambulance

Responsibilities of anaesthetic team:

- Continue resuscitation
- Secure airway and ventilate as indicated
- Facilitate transfer to CT scan
- Package on transport equipment and trolley
- Provide transport team e.g. experienced trained clinician or consultant with ODP or ICU nurse

Responsibilities of Embrace:

- Facilitate referral to neurosurgeon
- Provide advice on transfer of images
- Liaise with PICU regarding post-operative bed
- Provide on-going transfer post-op if PICU bed not available

Responsibilities of neurosurgical team:

- Review CT scan images
- Clear advice on need for ‘time critical neurosurgical transfer’

- Feedback to referral DGH team within 30 minutes of referral
- Inform referral DGH team of where child should be transferred to e.g. A&E, theatres, PICU

Stabilisation priorities:

Refer to "Time Critical Transfers - Preparing a patient" and "Time Critical Transfers - Equipment" at **www.sheffieldchildrens.nhs.uk/embrace**

Airway & C-spine control:

- Intubate as required; indications include:
  - GCS less than 9 or rapid decrease in GCS
  - Signs of raised ICP e.g. pupil asymmetry, Cushing's triad
  - Loss of airway reflexes
  - Insufficient ventilation
  - Spontaneous hyperventilation ($PaCO_2$ less than 3.6kPa)
- Confirm position with CXR
- Gastric tube on free drainage

Breathing:

- Monitor $ETCO_2$ (aim for 4.5 – 5.0kPa)
- Check blood gas before transporting and correlate to $ETCO_2$
- Aim for saturations more than 95% and PaO_2 12 - 16 kPa. Do not hyper-oxygenate
- PEEP at least 5, PIP to move the chest adequately, age appropriate Ti and rate

Circulation and haemorrhage control:

- 2 patent well secured IV lines
- Identify and treat life threatening haemorrhage
- Maintain arterial blood pressure to provide adequate Cerebral Perfusion Pressure (CPP)

Age (in years)	Mean BP (mmHg)	Systolic BP (mmHg)
<1	> 55	> 70
2-5	> 60	> 80
6-12	> 70	> 90
>12	> 80	> 100

- Ensure adequate circulating volume and use noradrenaline as required
- Noradrenaline can be given via an IO needle
- Do NOT delay transfer for difficult central or arterial access

Disability:

- Monitor and document pupils every 15 minutes
- Sedate adequately and muscle relax as required
- Phenytoin infusion en route for seizure activity
- Site a urinary catheter
- Treat raised ICP (as judged by changes to pupillary response and/or Cushing's triad)
- If there is clinical evidence of an expanding focal lesion give:
  - 20% mannitol 500mg/kg (equivalent to 2.5 mls/kg/dose)
  - **or**
  - 2.7% or 3% sodium chloride 3-5 mls/kg over 20 minutes
- This is a short term temporising measure and in the absence of a focal lesion, administration should be based on neurosurgical advice
- Following administration of mannitol, monitor the urine output; if a large diuresis ensues colloid may be required to maintain BP

- In the face of continuing deterioration consider further mannitol or hypertonic saline and / or hyperventilation to a $PaCO_2$ of 4.0 – 4.5 kPa

Exposure

- Maintain normothermia
- Maintain normal blood sugar
- 2/3rd restricted maintenance fluid 0.9% sodium chloride +/- glucose

Preparation and packaging

- Secure on ambulance trolley with appropriate harness
- Elevate head end to 30 degrees
- Ensure adequate oxygen for the journey
- Ambubag, mask and airway immediately available
- Fentanyl boluses (5micrograms/kg) and mannitol and/or 2.7/3% sodium chloride should be available for rapid changes in ICP
- Request smooth steady transfer with lights and sirens
- Seatbelts to be worn when vehicle moving

Documentation:

- Copy of notes, results, observation chart
- X-rays and scan via PACS or on CD

Parents:

- Contact details recorded
- Provide directions to destination hospital and telephone number

Pre-departure and on route:

- Inform destination unit and neurosurgeon of departure (this can be done via Embrace if required)
- Check which department of the hospital you are going to
- Observations recorded every 15 minutes
- Update destination unit and/or neurosurgeon if deterioration

3.2 Other time-critical transfers (non-trauma)

Refer to the regional Paediatric Trauma Guidelines to support the care of children with life threatening injury.

Additional supportive information and documentation is provided in the regional Safe Transport of Paediatric Patients (STOPP) tool found at www.sheffieldchildrens.nhs.uk/embrace

Definition:

Transfer of a patient for life, limb or organ saving treatment when the time taken to provide that treatment is a critical factor in outcome

- Time critical transfer should normally be provided by the referring hospital team **NOT** Embrace
- Acceptance by the regional centre is **NOT** bed dependent

Communication:

- **Contact Embrace on 0114 268 8180**
- State clearly that the patient requires a transfer and use **SBAR**
- Resuscitation, stabilisation and preparation for transfer should continue in parallel to the referral call
- If time critical transfer by the referring hospital is required it will be clearly stated by the Embrace consultant at the end of the call

Responsibilities of paediatric team:

- Consultant paediatrician should be present
- Start resuscitation and inform anaesthetic team immediately if airway support and/or critical care is required
- Refer to relevant specialist via Embrace
- Call for a 999 ambulance
- Provide transport team for patients requiring paediatric care e.g. APLS competent clinician with paediatric nurse

Responsibilities of anaesthetic team:

- Continue resuscitation
- Secure airway and ventilate as indicated
- Package on transport equipment and trolley
- Provide transport team for patients requiring critical care e.g. experienced trained clinician or consultant with ODP or ICU nurse

Responsibilities of Embrace:

- Facilitate referral to relevant specialists
- Provide advice on transfer
- Liaise with PICU regarding bed if required

Stabilisation priorities:

Refer to “Time Critical Transfers - Preparing a patient” and “Time Critical Transfers - Equipment” at www.sheffieldchildrens.nhs.uk/embrace

Airway & C-spine control:

- Intubate as required
- Confirm position with CXR
- Gastric tube on free drainage

Breathing:

- Monitor $ETCO_2$
- Check blood gas before transporting and correlate to $ETCO_2$
- Aim for saturations more than 94-98% and PaO_2 12 - 16 kPa
- PEEP at least 5, PIP to move the chest adequately, age appropriate Ti and rate

Circulation and haemorrhage control:

- 2 patent well secured IV lines
- Identify and treat life threatening haemorrhage
- Maintain arterial blood pressure to provide adequate Cerebral Perfusion Pressure (CPP)
- Ensure adequate circulating volume

- Do NOT delay transfer for difficult central or arterial access

Disability:

- Sedate adequately and muscle relax as required

Exposure:

- Maintain normothermia
- Maintenance fluids 0.9% sodium chloride +/- glucose

Preparation and packaging:

- Secure on ambulance trolley with appropriate harness
- Elevate head end to 30 degrees
- Ensure adequate oxygen for the journey
- Ambubag, mask and airway immediately available
- Request smooth steady transfer with lights and sirens
- Seatbelts to be worn when vehicle moving

Documentation:

- Copy of notes, results, observation chart
- X-rays and scan via PACS or on CD

Parents:

- Contact details recorded
- Provide directions to destination hospital and telephone number

Pre-departure and on route:

- Inform destination unit of departure (this can be done via Embrace if required)
- Check which department of the hospital you are going to
- Observations recorded every 15 minutes
- Update destination unit if deterioration

SECTION 4

HIGH FLOW NASAL CANNULA OXYGEN THERAPY (HFNCT)

4.1 Summary

Children may require respiratory support for many reasons. Non-invasive respiratory support may reduce the frequency with which children require mechanical ventilation. Two modes are readily available:

- High Flow Nasal Cannula Oxygen Therapy (HFNCT)
- Continuous Positive Airway Pressure (CPAP)

HFNCT was introduced to paediatric practice with no evidence to support its use. There are now several randomized controlled trials supporting the use of HFNCT in small children with moderate to severe bronchiolitis.[1,2] These studies do not support the concept of HFNCT as a therapeutic modality; it is simply another way of supporting breathing. Although the evidence supports the use of HFNCT, there is still debate over whether it is "better" than low flow oxygen or CPAP. There is some evidence from early studies in infants to suggest that HFNCT may be as effective as CPAP whilst being simpler to administer.[3,4] Research is on-going and will inform our future practice.

The above is important to understand as inappropriate use of HFNCT may lead to deferred escalation of care and worse outcomes. Inappropriate use of oxygen therapy can also be detrimental to the patient. There are a limited number of high flow devices and so it is important that they are used appropriately. The decision to start HFNCT should be by a senior decision maker (ST4 or above, or trained Advanced Practitioner) and should always be discussed with the consultant responsible for the patient.

The following is a guide aimed predominantly at the use of HFNCT for the management of infants and children with acute respiratory illness, WITHOUT pre-existing co-morbidity. There is a section at the end of the document for the management of children with pre-existing co-morbidity who may require a different approach. **This guide is not for use on the Neonatal Unit**.

Different devices are available to deliver HFNCT, the most commonly used in Yorkshire & Humber being the Vapotherm, Airvo or Optiflow. Different devices have advantages and disadvantages and the settings on one device are not directly comparable with another. The settings used in this document refer to Vapotherm as this is the most commonly used device in Leeds. If Airvo or Optiflow is used in the acute management of a child, the same starting settings may be used, but will require closer observation and more frequent adjustment to ensure the child is getting adequate support.

4.2 Indications for the use of HFNCT

Consider additional respiratory support with HFNCT if, despite optimising treatment/other manoeuvres to optimise respiratory condition, two or more of the following are present:

- Respiratory rate scoring 3 (amber) or more on PAWS, or amber / red on any other early warning score
- Apnoeas in infants less than 6 months of age with probable bronchiolitis
- Bradypnoea or cyanotic episodes (with or without bradycardia) despite supplemental oxygen
- Significantly increased respiratory effort including recession
- Need for high oxygen flow rate via nasal prongs (max 2-4L/min depending on comfort and age of child), facemask (8-10L/min), or headbox (consider if requiring 50-60%)
- Inability to achieve target saturations with, or to tolerate, other modes of oxygen delivery
- $PaCO_2$ 8.5 kPa or more (in children without pre-existing chronic lung disease) on a capillary blood gas
- Rising $PaCO_2$ (more than 2kPa from baseline)
- Respiratory acidosis (pH 7.2 – 7.28, if pH less than 7.2 consider intubation and ventilation)

HFNCT should not be used as a routine oxygen delivery system for children due to its cost and the scarcity of machines.

Special Considerations in the use of HFNCT

Patients in this group must be discussed with the Paediatric Consultant responsible for the patient before HFNCT is started as other options may be preferable.

- Pre-existing lung disease/ Cardiac conditions
- Neuromuscular disorders
- Thoracic abnormalities
- Patients with an initial pH< 7.2 who don't meet other indications, (i.e. could this be something else such as a metabolic acidosis/sepsis)
- Small neonates with apnoeas (consider sepsis)
- Asthma – NOT standard therapy, therefore would need a discussion with PICU via Embrace. If started, it should be in parallel with and not delay standard asthma therapy, such as IV bronchodilators. Standard nebulisers should not be used at the same time as HFNCT as this is not an efficient form of drug delivery. A device called an Aerogen nebuliser is required to enable nebulised drug delivery with HFNCT. Currently it is recommended that asthmatics on HFNCT requiring nebulised therapy should also be on IV bronchodilators and in a critical care setting.
- Croup - NOT standard therapy, therefore would need a discussion with PICU via Embrace. If started, it should be in parallel with and not delay standard croup and airway management.

When starting a child on HFNCT, an appropriate clinical risk assessment needs to be made. Consider whether the child needs to be looked after in a stabilisation area, or another area where level one paediatric critical care can be delivered safely. Please consider staffing and equipment availability.

COVID19 is not a contraindication to HFNCT. The RCPCH and UK PCCS have put out statements to the effect that if a child has or is suspected to have COVID19, HFNCT can be used if the child is hypoxic despite low flow oxygen, with appropriate PPE. It has been used without an increased risk of health care worker infection in adult centres both nationally and internationally.
Please see guidance on PPE here https://www.england.nhs.uk/coronavirus/secondary-care/infection-control/ppe/

Contraindications to the use of HFNCT

- The need for intubation and/or mechanical ventilation as evidenced by the presence of:
  - Severe respiratory or cardiovascular instability and impending arrest
  - pH less than 7.20 and not improving with initial support
  - SpO_2 less than 88% in maximal effective oxygen therapy
  - Exhaustion (decreasing respiratory rate, desaturations, apnoea and increasing heart rate or bradycardia may indicate fatigue)
- Upper airway abnormalities that may make HFNCT, NCPAP, or Nasal Mask (NM)-CPAP ineffective or potentially dangerous (e.g., choanal atresia, cleft palate, tracheoesophageal fistula)
- Pneumothorax
- Burns to the face/ chest

4.3 How it works

HFNCT is a system by which warmed and humidified high flow oxygen/air mixture is administered via nasal cannulae at flow rates more than 2 l/min [5]. It can be used by trained staff to provide respiratory support for infants who would be considered for CPAP therapy.

HFNCT delivery systems work by producing gas flows that exceed patient inspiratory flow rates. This ensures that the patient inspires the intended gas composition and may provide other physiological benefits including:

- Washout of nasopharyngeal dead space
- Reduction in inspiratory resistance associated with gas flow through the nasopharynx
- Improvement in respiratory mechanical parameters associated with gas temperature and state of humidification, such as ciliary function.
- Reduction in metabolic work associated with heating and humidification of gas
- Provision of mild distending pressures[5,6]

It is not intended for use as a continuous positive airway pressure device, but rather as a high flow system to deliver conditioned (i.e. warmed and humidified) breathing gases.[5]

Advantages

- More comfortable, with less risk of nasal trauma than with CPAP
- Less nursing time required as easier to use than CPAP, not dependent on seal
- Easier access to child than CPAP (and head box oxygen in infants)
- Easier parental interaction with their child

Potential Disadvantages

- Unpredictable delivery pressures which are not measured (however the circuit pressure will always be significantly greater than pressure within the nasopharynx), [5] and there have been case reports of barotrauma. [7]
- The HFNCT unit cannot be used to transfer patients between areas within the hospital.
- The HFNCT unit has very limited battery and so should not be used in situations where power supply is unreliable.
- Due to the above limitations the patient needs to be in a room with oxygen and it can make interventions such as radiological investigations challenging.
- Standard nebulisers should not be used at the same time as HFNCT as it will prevent drug delivery. A device called an Aerogen nebuliser is required to enable drug delivery with HFNCT.

Set up

- HFNCT is applied to children via nasal cannulae, and is attached to a continuous flow of warm, humidified air and oxygen.
- It is intended as an open system, which allows for flushing of nasopharyngeal dead space.
- Select appropriate sized nasal cannula for that child. These must not occlude more than 50% of the child's nostrils
- The mouth must not be held closed
- Select appropriate circuit
- Select the initial flow rate using Table 1
- Stop feeds initially (See fluid management below)
- See equipment and personnel requirements below

Nasogastric tubes:

- Insert if required for feeding
- Observe the child for gastric distension and pass an NG tube if it occurs. Leave on free drainage
- Please use local guidance for nasogastric feeding

Management

Start with FiO_2 at 60% and the starting flow rate – weight related. ***(See Table 1)***
Set target SpO_2 for child (normally 92 -95%) - this may need to be lower in children with chronic lung disease or congenital heart disease.

Ensure nares are not occluded by more than 50%. The cannula can be sat below the nostrils.

Table 1

Weight range	Minimum Flow litres/min	Starting Flow litres/min	Maximum Flow litres/min
< 3kg	5	6	8
3 – 3.9 kg	5	8	12
4 – 7.9 kg	8	10	15
8 – 11.9 kg	10	15	20
12 – 19.9 kg	12	20	25
20 – 29.9 kg	16	25	40
≥ 30kg	20	30	40

Blood gases

- Check a capillary gas before starting HFNCT
- If pH less than 7.2 – consider if intubation and ventilation is required
- pH 7.2 – 7.25 – start HFNCT. Observe closely. **Repeat the gas within 1 hour and contact the on duty consultant with the result**
- pH more than 7.25 and clinically improving on HFNCT – **no need to repeat gas unless there is a change in the patient's condition.**

Supportive Care

- Stop feeds initially; Start 80% maintenance IV fluids as per local fluid guideline
- Consider prone positioning
- Consider chloral hydrate 25mg/kg (max 1 gram four times a day), initially 6 hourly, in unsettled babies as chloral does not cause apnoeas in the majority of patients. Only use in children with normal or improving blood gases.
- If the child is irritable then consider other causes e.g. hypoxia, hypercapnia, meningitis.
- Do not administer chloral hydrate in small babies with apnoeas / those with poor muscle tone or those with any other contra-indication to chloral hydrate
- Once stable / improving:
    - Consider nasogastric feeds after 4 hours of therapy if the patient is stable
    - Oral feeds can be considered in patients who have mild - moderate respiratory distress and are improving after discussion with the consultant.

Monitoring

- Continuous HR and SpO2 monitoring
- Half hourly recording of RR, HR, SpO2, PAWS for the first 2 hours, with 4 hourly temperature, BP and AVPU score
- 4 hourly observations once stable/improving
- Fluid balance
- Measure daily urea and electrolytes if on intravenous fluids

4.4 Assessment, escalation and weaning

See Appendix 2. – High Flow – assessment, escalation and weaning (Flow-chart)

If SpO_2 less than 92% **or below prescribed target range**

- Temporarily increase FiO_2 to 80% and increase the flow by increments of 2 litres / min up to the maximum (see Table 1)
- Urgent medical review
- Consider anaesthetic review
- If SpO_2 is still less than 92%, increase FiO_2 to 100%
    - Urgent review of ABC and intervention as necessary
    - Check circuit and the position of the cannula
    - Exclude causes for failure including nasal obstruction, pneumothorax, gastric distension leading to diaphragmatic splinting
    - If the situation is not resolved, discuss with consultant and call Embrace
    - Some patients may be managed with high settings on a paediatric ward after discussion with PICU if the consultant responsible for the patient agrees.
    - Once condition stabilises wean FiO_2 as tolerated.

If SpO_2 more than 95% or prescribed target range

- Reduce FiO_2 in 10% increments as tolerated until SpO_2 in target range or greater than 95%.
- Once FiO_2 is 40% then consider reducing flow
- Review FiO_2 with every set of observations at least (i.e. every 4 hours or more frequently if possible) and reduce accordingly.

- If following reduction in FiO_2 to 40%, SpO_2 remains more than target range or greater than 95% and clinical observations and PAWS are stable after at least 2 hours of HFNCT, reduce flow by 2 litres per minute increments as tolerated, until SpO_2 is in target range. Consider weaning at every set of observations.
- If SpO_2 remains more than target range or greater than 95% and flow rate has reached minimum weight-appropriate thresholds (see Table 1), the child should have a trial off HFNCT on low flow oxygen (unless it was started for apnoeas or airway obstruction).
- If target saturations are not maintained after flow or FiO_2 are reduced then go back to previous settings.

Children should be weaned from HFNCT to other modes of oxygen therapy as soon as safely possible to ensure a supply of machines for other children who need them.

Success of treatment can be gauged by:

- Reduction in frequency/ severity of apnoea
- Reduction in oxygen requirement
- Reduction in heart rate and respiratory rate within the first hour (but beware of fatigue!)
- Improvement in respiratory acidosis
- Reduction in work of breathing

Failure of treatment can be gauged by:

- Increasing oxygen requirement
- Unchanged / rising heart rate and respiratory rate
- Failure to improve respiratory acidosis (pH <7.2)
- An unchanged or increased work of breathing
- SpO_2 less than 92% at FiO_2 more than 60% and maximal weight-appropriate flow rate
- Fatigue (falling respiratory rate with increasing heart rate; apnoeas; bradycardias; desaturations)

<u>If HFNCT is failing:</u>

(pH less than 7.2, unable to maintain saturations in target range or increase in work of breathing):

- Urgent review of ABC and intervention as necessary
- Call anaesthetist
- Consider calling 2222
- Check, equipment, circuit and nasal cannulae position
- Consider chest X-ray
- Consider complications:
    - Barotrauma; pneumothorax or subcutaneous emphysema
    - Sudden deterioration requiring immediate ventilation
    - Aspiration
    - Gastric distension and diaphragmatic splinting
    - Obstruction or irritation due to improper sizing of nasal cannulae
- Review diagnosis, consider:
- Nasal obstruction
- Lung collapse/secretions (consider physiotherapy)
- Pneumothorax
- Gastric distension
- Sepsis/ metabolic/ cardiac causes
- Undiagnosed neuromuscular disorder
- Consultant paediatrician review
- Refer to PICU via Embrace

<u>Discontinuation of HFNCT</u>

- Need for intubation and ventilation
- Intractable gastric distension and diaphragmatic splinting
- Improvement, therefore able to wean

- If no progress by day 3 (48 - 72hours):
    - discuss with consultant
    - review diagnosis / co-morbidity
    - consider other therapies

4.5 Equipment and personnel requirements

- Commercially available nasal prongs
- Continuous flow air & oxygen gas source
- HFNCT delivery device
- Continuous pulse oximetry, with audible alarm settings
- Suction source, suction regulator, and suction catheters
- Resuscitation apparatus and masks of appropriate size

HFNCT can be used in all paediatric units able to deliver Level one paediatric critical care if the following criteria are met:

- Nursing staffing levels are adequate to ensure initial one nurse to two patient ratio until the patient is stable
- Nursing staff have received training and are competent to care for patients with HFNCT
- Adequate medical staff cover exists to ensure frequent review of patients on HFNCT

4.6 Transfer of children on HFNCT

Children on moderate flows and in less than 50% oxygen can be moved between ward areas temporarily off HFNCT. Patients made distressed with mask can be transferred on nasal cannula with a suction control unit adaptor. Children who need more support will need a medical escort who is capable of providing bag mask ventilation including PEEP.

Once a child has arrived in the new area, a doctor or nurse should stay with the child until HFNCT has re-commenced and the staff are happy with the child's clinical condition.

4.7 Complex patients

- Patients who have underlying respiratory or neuromuscular comorbidity may not wean easily from high flow. These patients should be discussed with a consultant in paediatric respiratory medicine or a consultant paediatric intensivist.

- It is unreasonable to expect a child with chronic lung disease who requires oxygen at home to be weaned to less than 40% before going on to wall oxygen. It is therefore more important to wean the flow, as high flows cannot be used at home.

- The smaller the child the greater the effect of PEEP, and so will be more sensitive to flow. Large children/adolescents will be less responsive to flow rates and will require higher flow rates.

- Therefore for chronic lung disease children, we should reduce flow but may need to tolerate higher oxygen requirements (eg 40%) when switching to low flow.

- Patients with neuromuscular problems may be receiving an unmeasurable benefit from the PEEP effect of HFNCT. These patients often benefit from NIV, if appropriate, rather than HFNCT.

- If a child cannot be weaned from HFNCT after 2 weeks, the patient should be discussed with a consultant in paediatric respiratory medicine regarding further management and investigation.

Provenance

We would like to thank the following authors from the Leeds Children's Hospital for giving their permission for their guideline to be adapted for use across hospitals in the Yorkshire & Humber region:

Dr Chris Edwards, Consultant in Paediatric Respiratory Medicine
Dr Evie Robson, Consultant in Paediatric Respiratory Medicine
Dr Jo Lumsden, Consultant Paediatric Intensivist
Dr Chris Smith, Consultant Paediatrician
Sharon Coulson, Sister in Paediatric Intensive Care
Ann McDermott, Sister in Paediatric Intensive Care

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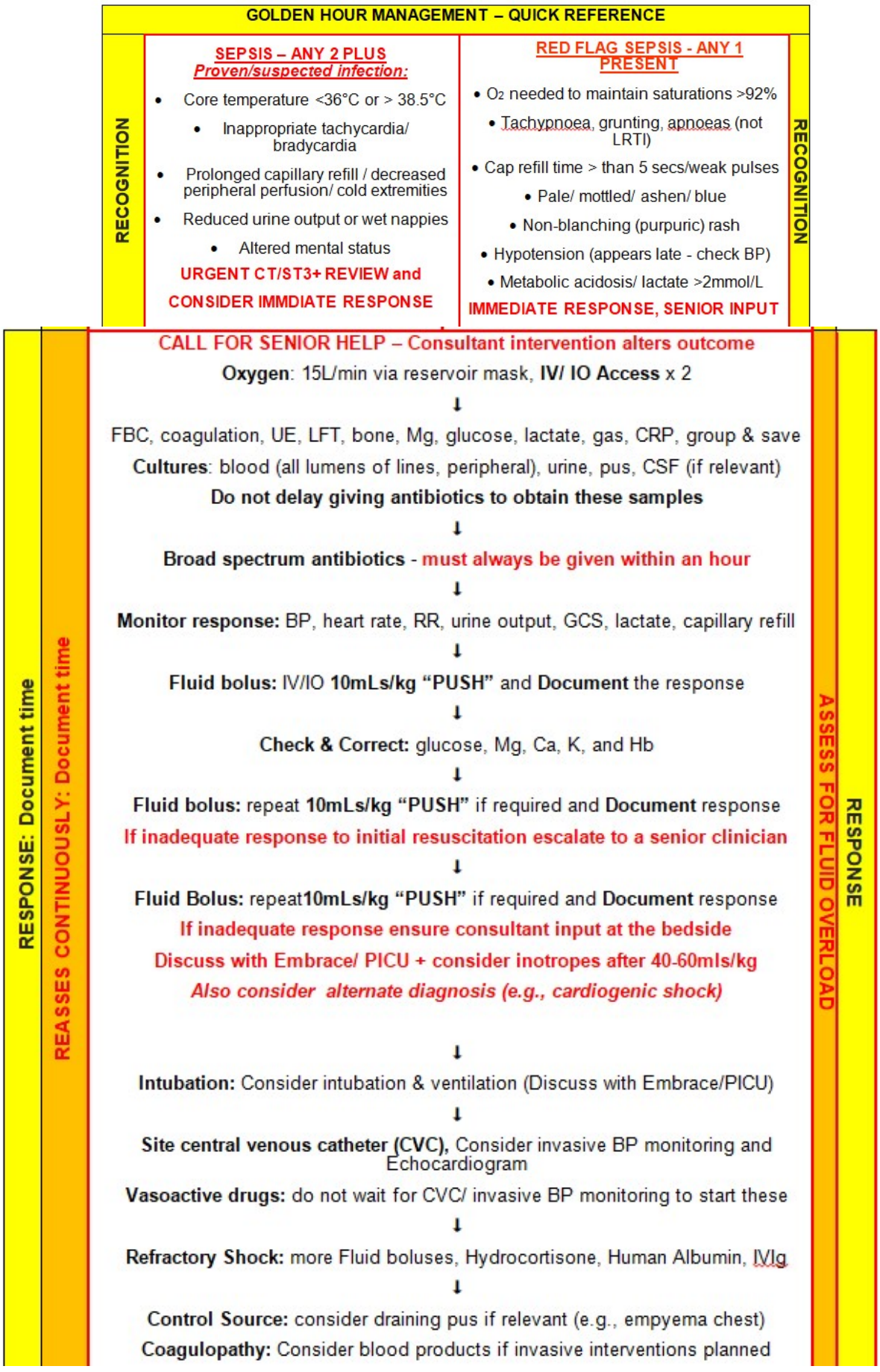
SECTION 5

SEPSIS - RECOGNITION AND TREATMENT

Adapted from Sheffield Children's NHS Foundation Trust Sepsis Guideline 2020 authored by Dr Ella Dzora

This guideline intends to improve outcomes by aiding clinicians in the early recognition and management of sepsis and septic shock. All febrile, unwell children should be assessed to rule out sepsis.

5.1


GOLDEN HOUR MANAGEMENT – QUICK REFERENCE
RECOGNITION
SEPSIS – ANY 2 PLUS
Proven/suspected infection:
• Core temperature <36°C or > 38.5°C
• Inappropriate tachycardia/ bradycardia
• Prolonged capillary refill / decreased peripheral perfusion/ cold extremities
• Reduced urine output or wet nappies
• Altered mental status
URGENT CT/ST3+ REVIEW and CONSIDER IMMDIATE RESPONSE
RED FLAG SEPSIS - ANY 1 PRESENT
• O2 needed to maintain saturations >92%
• Tachypnoea, grunting, apnoeas (not LRTI)
• Cap refill time > than 5 secs/weak pulses
• Pale/ mottled/ ashen/ blue
• Non-blanching (purpuric) rash
• Hypotension (appears late - check BP)
• Metabolic acidosis/ lactate >2mmol/L
IMMEDIATE RESPONSE, SENIOR INPUT
RECOGNITION
RESPONSE: Document time
REASSES CONTINUOUSLY: Document time
CALL FOR SENIOR HELP – Consultant intervention alters outcome
Oxygen: 15L/min via reservoir mask, IV/ IO Access x 2
FBC, coagulation, UE, LFT, bone, Mg, glucose, lactate, gas, CRP, group & save
Cultures: blood (all lumens of lines, peripheral), urine, pus, CSF (if relevant)
Do not delay giving antibiotics to obtain these samples
Broad spectrum antibiotics - must always be given within an hour
Monitor response: BP, heart rate, RR, urine output, GCS, lactate, capillary refill
Fluid bolus: IV/IO 10mLs/kg "PUSH" and Document the response
Check & Correct: glucose, Mg, Ca, K, and Hb
Fluid bolus: repeat 10mLs/kg "PUSH" if required and Document response
If inadequate response to initial resuscitation escalate to a senior clinician
Fluid Bolus: repeat10mLs/kg "PUSH" if required and Document response
If inadequate response ensure consultant input at the bedside
Discuss with Embrace/ PICU + consider inotropes after 40-60mls/kg
Also consider alternate diagnosis (e.g., cardiogenic shock)
Intubation: Consider intubation & ventilation (Discuss with Embrace/PICU)
Site central venous catheter (CVC), Consider invasive BP monitoring and Echocardiogram
Vasoactive drugs: do not wait for CVC/ invasive BP monitoring to start these
Refractory Shock: more Fluid boluses, Hydrocortisone, Human Albumin, IVIg
Control Source: consider draining pus if relevant (e.g., empyema chest)
Coagulopathy: Consider blood products if invasive interventions planned
RESPONSE
ASSESS FOR FLUID OVERLOAD

5.2 Treatment

RESUSCITATION FLUID

- Plasma-Lyte 148/ buffered solution or 0.9% Sodium Chloride
- Packed Red Blood Cells if haemoglobin is <70 g/dL and/or central venous oxygen saturation <70% (via a internal jugular/ subclavian central venous catheter if in situ)

RESUSCITATION GOALS to achieve normal perfusion

- Equal quality central and peripheral pulses
- Capillary refill time less than 3 seconds
- Warm extremities: temperature gradient – central to peripheral
- Normal HR, RR, BP (target Mean BP 5th – 50th centile for age) – **monitor every 5 mins**
- Urine output > 1mL/kg/hour (place urinary catheter after initial resususcitaiton completed)
- Serum lactate <2 mmol/L (may be high on adrenaline infusion)

Look for fluid overload: Intubate & ventilate early if hepatomegaly/ new lung crackles

FLUID REFRACTORY SHOCK i.e., normal perfusion not restored after 60 mLs/kg fluid:

Consider endotracheal intubation and ventilation in the following:

- Respiratory failure, signs of exhaustion, impending cardiovascular collapse
- Decreased/ fluctuating consciousness (GCS ≤ 8, AV**PU**), raised intracranial pressure

Preparation and procedure:

- Prepare fluid boluses, and adrenaline and atropine for rescue
- Ketamine 0.5 - 2mg/kg (low dose if haemodynamically unstable), Rocuronium 1mg/kg
- Use a cuffed endotracheal tube, an uncuffed tube may be used in neonates
- Avoid nasal endotracheal tube if suspected/ confirmed coagulopathy/ thrombocytopaenia

Post intubation*:*

- Early chest x-ray: check endotracheal tube position, exclude pneumonia/ effusion
- High PEEP if pulmonary oedema/ acute respiratory distress syndrome

VASOACTIVE AGENTS

Treatment	Recommended Vasoactive agents*: Discuss with PICU at each stage*
1st line	Adrenaline/ Noradrenaline
2nd line	Milrinone
3rd line	Vasopressin

- Gain central venous access urgently but DO NOT delay commencing vasoactive drugs
- Adrenaline, Noradrenaline, Milrinone, (Dopamine and Dobutamine) may be given via peripheral veins
- Dopamine/ Dobutamine may be used if Adrenaline and Noradrenaline are not available

- Intraosseous needle/ external jugular veins may be used in place of central venous access initially and in the short term, monitor closely for extravasation
- Peripheral adrenaline: infuse at 0.1-1.5microgram/kg/minute - 1mg (1ml of 1:1000) in 50ml 0.9% sodium chloride (0.1microgram/kg/min = 0.3ml/kg/hr)
- Current recommendations are *not* to categorise shock as "warm" or "cold". Senior decision makers may choose drugs based on haemodynamic variables e.g., Noradrenaline as first line in patients with vasodilatation

CATECHOLAMINE RESISTANT SHOCK: hypotension despite two vasoactive agents

- Rule out failed delivery of drugs, pericardial effusion, pneumothorax, blood loss, and intracranial event
- Further fluid boluses: Plasma-Lyte 148, 0.9% sodium chloride, blood components or 4.5% human albumin
- Consider Hydrocortisone - 1mg/kg 6 hourly, (neonates 2.5mg/kg initially, see cBNF)
- Seek and control source of infection if easily done – e.g., drain empyema chest
- Consider IV Immunoglobulin 2g/kg in toxic shock/ secondary immunodeficiency

ADDITIONAL MONITORING OF RESPONSE TO THERAPY

- Invasive arterial blood pressure: target blood pressure to achieve adequate urine output
- Central venous pressure
- Central venous oxygen saturation >70% (via internal jugular venous catheter/ subclavian catheter)
- Echocardiography or Doppler to assess intravascular volume status and cardiac function
- FBC, biochemistry and coagulation 6 - 12 hourly

MONITOR ELECTROLYTES – TARGET RANGE and CORRECTION DOSES

- Blood glucose 4 – 12 mmol/L: 10% Glucose 2mL/kg
- Ionised Calcium >1.0 mmol/L: 10% Calcium gluconate 0.11mmol/kg (max 4.5mmol) over 5-10 mins (max 0.45mmol/min)
- Potassium 3.5 - 5.5 mmol/L: Potassium chloride 0.5-1mmol/kg (up to 40mmol) at 0.2mmol/kg/hr, may be repeated after 2 hours, Central: maximum concentration 0.5mmol/ml, Peripheral: maximum concentration 40mmol/L
- Magnesium >0.8 mmol/L: Magnesium 0.4mmol/kg (max 20mmol) over 10 mins

INDICATIONS: BLOOD PRODUCTS

Packed red blood cells:

- Haemoglobin <70 g/dL and/ or Central venous O_2 saturation <70%

Octaplas/ platelets/ cryoprecipitate:

- Coagulopathy with active bleeding and/ or before invasive procedures

Doses/ volumes

- Packed red blood cells 20mLs/kg
- Vitamin K 300 microgram/kg (max10mg)
- Octaplas 15 - 20mLs/kg

- Platelets 10mLs/kg
- Cryoprecipitate 5 - 10mLs/kg

5.3 RECOGNITION OF SEPSIS and SHOCK

In the early stages differentiating between a child with severe sepsis and one with a benign infection (especially infants) may be difficult as fever often causes abnormal physiological parameters, if in doubt, seek senior guidance. In ***any*** unwell, febrile child or young person ask; consider sepsis as a diagnosis. Temperature <36°C in an unwell child may also represent sepsis. Plot the observations and use an early warning score to flag abnormal physiological parameters (heart rate, respiratory rate, blood pressure).

Screening tools that may be useful:

- Red flag sepsis - Golden Hour flowchart
- NICE traffic light system – age appropriate

Note patients with neurodisability, learning difficulties and autistic spectrum disorder may not present with typical symptoms and signs. Have a high index of suspicion if there is a change from baseline.

High risk groups: have a higher index of suspicion and lower threshold to treat.

Underlying disease / co-morbidities:

- Neuromuscular disease – remember, may not show typical signs
- Malignancy and/or chemotherapy treatment - check for neutropenia
- Immunodeficiency – primary or secondary

Age <6 months

- Neonates: risk of Gram negative sepsis, especially in those with possible galactosaemia, Risk of Group B Streptococcus, Herpes simplex virus

Recent / Concurrent illnesses :

- Post-operative patients
- Concurrent/recent chicken pox within last 6-8 weeks: risk of invasive Group A Streptococcus and *Staphyloccocus aureus*
- Recent burns: risk of invasive Group A Streptococcus and *Staphyloccocus aureus*
- Post Influenza A or B: risk of *Streptococcus pneumoniae*, *Neisseria meningitidis*, invasive Group A Streptococcus, *Staphylococcus aureus*
- Chronic infection - carriers of Pseudomonas, ESBL, MRSA, multi-resistant organisms

Indwelling plastic / metal

- Ventriculoperitoneal shunt, vascular catheter, prosthesis, fixation/ frames, indwelling urethral catheter, gastrostomy

PRINCIPLES of IDENTIFICATION, CONTROL and TREATMENT of INFECTIOUS SOURCE:

Identification:

- Take a thorough history. Include travel, contacts, and immunisation status
- Examine respiratory and cardiac system, abdomen, bones, joints, skin, ENT if safe to do so, wounds, sites of catheter/ indwelling devices/ prostheses/ metalwork.
- Consider chest x-ray and other appropriate imaging to identify source.

Source Control:

- Matters to consider and discuss with appropriate teams:
- Remove indwelling catheters, remove/ lock vascular catheters with an antibiotic, sanitary tampons, drain abscesses/ empyema, debride wounds, remove metalwork

Antimicrobial Treatment: START SMART, THEN FOCUS

- Antimicrobials targeted to suspected source of infection. Start broad if microbe unknown and give as early as possible – **within an hour of decision to treat**.
- Discuss with senior clinician and/or microbiologist if any allergies/ contraindications to recommended antibiotics or if complex clinical case or history of known chronic carriage of microbes e.g., *Clostridium difficile*

Patient specific considerations:

- Modify dose for liver/renal function if appropriate
- Obese children – Refer to the 'Drug dose adjustments in obese patients' guidelines, IBW may need to be used for some antibiotics. Do not exceed adult maximum doses.
- Older children – Do not exceed adult maximum doses

Review of antimicrobial treatment:

- Reassess - identify source of infection/ check microbiology results and rationalise antibiotic choice as soon as possible
- Enteral route - consider switching to enteral route as soon as clinically practicable
- End date - make decision on length of course

Suspected/ confirmed bacterial meningitis in > 3 months old

- Dexamethasone 0.15mg/kg 6 hourly (maximum 10mg) for 4 days. First dose within 4-12 hours of starting antibiotics. Treat raised intracranial pressure promptly (refer to meningococcal guidelines).

Traffic light System for identifying risk of serious illness

	Green – low risk	Amber – Intermediate risk	Red – high risk
Colour (of skin, lips or tongue)	• Normal colour	• Pallor reported by patient / carer	• Pale / mottled / ashen / blue
Activity	• Responds normally to social cues • Content / smiles • Stays awake or awakens quickly • Strong normal cry / not crying	• Not responding normally to social cues • No smile • Wakes only with prolonged stimulation • Decreased activity	• No response to social cues • Appears ill ro a healthcare professiona; • Does not wake or if roused does not stay awake • Weak, high-pitched or continuous cry
Respiratory	•	• Nasal flaring • Oxygen saturations ≤95% in air • Crackles in the chest • Tachypnoea: - RR >50 breaths/minute age 6-12 months - RR >40 breaths/minute age >12 months	• Grunting • Tachypnoea RR >60 breaths/minute • Moderate or severe chest indrawing
Circulation and Hydration	• Normal skin and eyes • Moist mucous membranes	• Tachycardia - >160 beats/minute age <12 months - >150 beats/minute age 2-5years - >140 beats/minute age >12 months • CRT ≥3 seconds • Dry mucous membranes • Poor feeding in infants • Reduced urine output	• Reduced skin turgor
Other	• None of the amber or red symptoms or signs	• Age 3-6 months temperature >39ºC • Fever for ≥5 days • Rigors • Swelling of a limb or joint • Non-weight bearing limb / not using an extremity	• Age <3 months temperature ≥38ºC • Non-blanching rash • Bulging fontanelle • Neck stiffness • Status epilepticus • Focal neurological signs • Focal Focal signs

CRT = Capillary Refill Time; RR = Respiratory Rate
*** Some vaccinations have been found to induce fever in children aged under 3 months**

This traffic light table should be used in conjunction with the recommendations in the NICE guideline on fever in under 5's https://www.nice.org.uk/guidance/ng143

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SECTION 6

DUCT DEPENDENT CONGENITAL HEART DISEASE

Access the regional guideline on use of Dinoprostone in duct dependent congenital heart conditions:

https://www.networks.nhs.uk/nhs-networks/yorkshire-and-humber-congenital-cardiac-network/guidelines-and-protocols/dinoprostone-guideline/file_popview

SECTION 7

MANAGEMENT OF CHILDREN WITH CONVULSIVE STATUS EPILEPTICUS

7.1 Introduction

This guideline is for anaesthetists working in partnership with their paediatric colleagues who are called to help with the management of children who present to hospital in convulsive status epilepticus (CSE).

It should be used in conjunction with local guidelines for paediatricians for the management of convulsive status epilepticus.

Updated algorithms for Status Epilepticus Management are available here:

1. Advanced Paediatric Life Support 7th Edition Algorithm for Status Epilepticus Management (Appendix 3).
2. Resuscitation Council UK Treating convulsive status epilepticus in children RCUK Paediatric emergency algorithms and resources Mar 22 V1.pdf (resus.org.uk)

In children with known epilepsy check if there is an emergency care plan specific to the child on the electronic record or held by their parent/carer. Ask if they are already on levetiracetam, phenytoin or phenobarbitone, as this will influence the choice of drugs given.

7.2 Objective of guideline

The primary objective of this guideline is to promote the safe management of children in CSE by:

- Reducing the incidence of intubation secondary to respiratory depression
- Preventing unnecessary intubation
- Providing guidance on which children require a CT brain scan
- Identifying those children who fit clinical criteria for an early trial of extubation in the DGH
- Promoting management that enables safe extubation
- Providing guidance for safe extubation
- Identifying those children who need to be admitted to PICU

Convulsive status epilepticus is the second most common cause of admission to PICU, accounting for approximately 10% of PICU admissions nationally. A substantial proportion of these children are extubated within a few hours of their arrival at the PICU and returned to their referring hospital within 24 hours. This process exposes the child to the risks of transfer, causes distress and inconvenience to families and uses scarce PICU resources.

We encourage staff to extubate selected patients after episodes of CSE with advice from PICU consultants via Embrace. This guideline has been written to support the process.

Management of convulsive status epilepticus is a medical emergency: untreated CSE causes permanent brain injury. Furthermore, the longer fit has gone on for, the more difficult it is to stop.

Consider and treat the cause. In children, aetiology of CSE is as follows:

- 25% complex febrile convulsions (this is usually a retrospective diagnosis)
- 25% remote symptomatic (children with prior neurological abnormality)
- 25% idiopathic epilepsy
- 25% acute symptomatic requiring specific treatment
    - Traumatic brain injury, including abusive head trauma
    - CNS infection: meningitis, encephalitis, cerebral abscess, empyema
    - Encephalopathy: metabolic disease, poisoning, electrolyte disturbance
    - Space occupying lesion (tumour, haematoma or blocked VP shunt)
    - Acute hypoxic ischaemic insult
    - Cerebrovascular event
    - Sudden withdrawal of anti-epileptic drugs in child with epilepsy

Children require anaesthetic management during an episode of CSE for a number of reasons. These include:

- Respiratory depression and loss of airway reflexes.
- Respiratory failure possibly because of aspiration of gastric contents.
- Anaesthesia for CT scan
- As the final step in the CSE protocol which requires the administration of anaesthetics (e.g. thiopentone, proprofol[1] or midazolam) as an anticonvulsant.
- For stabilisation prior to transfer to a PICU.

Remember that, just because a child is still fitting at the time of arrival of the anaesthetist, **it is not always necessary to induce anaesthesia immediately.**

Induction of anaesthesia is the last step in the guideline, which should be followed to completion unless there are good reasons for not doing so. Almost all postictal children have some degree of respiratory depression and mixed acidosis with raised lactate and high $PaCO_2$. In the early post ictal phase it may be sufficient to support ventilation with a bag and mask with the child in the recovery position or by insertion of an airway adjunct. Consider insertion of large bore gastric tube.

In those children who are intubated to stop fits, an infusion of anticonvulsant (phenytoin of phenobarbitone) must be completed. Once the child is intubated follow the algorithm in Appendix 3.

Many children who are intubated during an episode of CSE can be safely managed in the DGH.

7.3 Indications for CT scan

Some, but not all children with CSE require an urgent CT brain scan. A CT scan may be needed to exclude space occupying lesions such as tumour, bleed or abscess. Ask for CT with contrast if meningitis or abscess is suspected. Remember that a normal CT scan does not rule out the possibility of raised intracranial pressure.

An urgent CT scan will be required if any of the following are present:

- Any child with CSE when aetiology is unknown
- Focal neurological signs including focal seizure
- Asymmetric or unreactive pupils
- Clinical suspicion of raised intracranial pressure
- Reduced conscious level one hour post seizure
- History of trauma
- Hydrocephalus with VP shunt in situ
- Suspicion of abusive head trauma

[1] Notes on the use of propofol.

- Propofol is not recommended for sedation on PICU
- It is not included among the recommended agents for termination of fits in children in the 2012 NICE guidelines –it is recommended for adults - although it is probably equally effective
- It is commonly used both as an induction agent and by infusion for maintenance of anaesthesia in children
- Anaesthetists are much more familiar with propofol than with thiopentone or midazolam
- We have, therefore, recommended that propofol should be considered for use as an agent to terminate fits and that it can be used for ***maintenance of anaesthesia*** in the post-ictal child up to the point of PICU admission.
- It remains the responsibility of the prescriber to decide on the risks and benefits of their actions

7.4 CT scan procedure

- Some postictal children are stable and will remain still enough for a CT scan of the head to be performed without further sedation.
- Those that require anaesthesia will require substantially reduced doses of induction agents (thiopentone or propofol) as they will already have received several sedative agents.
- A short acting muscle relaxant is preferable so that it is possible to confirm that the fits have stopped.
- The anaesthetic for CT scan should be delivered in such a way as to maximise the chances of extubating the child safely. We suggest the use of propofol either by infusion (up to 5mg/kg/hr) or as intermittent boluses or, if an anaesthetic machine is available, the use of a volatile anaesthetic agent.

If the fits have stopped then it is reasonable to evaluate whether the child fits criteria for a trial of extubation or is likely to need transfer to PICU.

7.5 Post intubation management

- Clinical examination: chest, cardiovascular system, neurology
- NG/OG tube, aspirated, then free drainage
- Ventilation to normocarbia
- CXR
    - Confirm tube (ETT and NG/OG) position
    - Examine lung fields (infection or aspiration; right upper lobe collapse is a common finding after CSE and does not preclude a trial of extubation)
- If decision to keep asleep rather than try to extubate, then titrated anaesthesia / sedation (propofol / volatile anaesthetic agent)
- Maintenance fluid infusion
- Close observation for further seizures
- Maintenance of normal body temperature (consider antipyretics)
- Monitoring & documentation
    - To AAGBI anaesthetic standards[2]
    - Pupils
    - Conscious level (GCS) after a decision to attempt to wake up
    - Blood glucose

7.6 Clinical criteria for early trial of extubation

- If CT brain scan was indicated, then this should show no evidence of acute pathology
- Seizures have stopped
- No signs of raised intracranial pressure and conscious level is improving
- Adequate cough and gag reflexes
- Cardiovascular stability.
- Adequate gas exchange (SpO_2 > 95% in up to 30% oxygen).

An adequate period of time should be allowed for the child to be awake enough to extubate. If they are not given additional anaesthetic agents after the seizure has stopped, then extubation is more likely to be successful. Consideration should be given to the child's fasting status at the time of extubation. Following a successful extubation the child should receive close monitoring in an appropriate area able to deliver level 1 paediatric critical care (high dependency care).

The trial of extubation has failed if:

- The child is not awake enough to extubate safely after 2 hours
- The child has further seizures

Seek advice from Embrace & PICU consultant.
At this point the child is likely to need transfer to PICU for further management.

[2] AAGBI; Recommendations for standards of monitoring during anaesthesia and recovery 2021 https://anaesthetists.org/Home/Resources-publications/Guidelines/Recommendations-for-standards-of-monitoring-during-anaesthesia-and-recovery-2021

Appendix 1- Exception Report Template

Yorkshire & Humber PCCODN

Exception Report

Child under 16 years of Age

Hospital Trust:

Date:

Name of person completing the Form:

Contact email:

Patient Details:

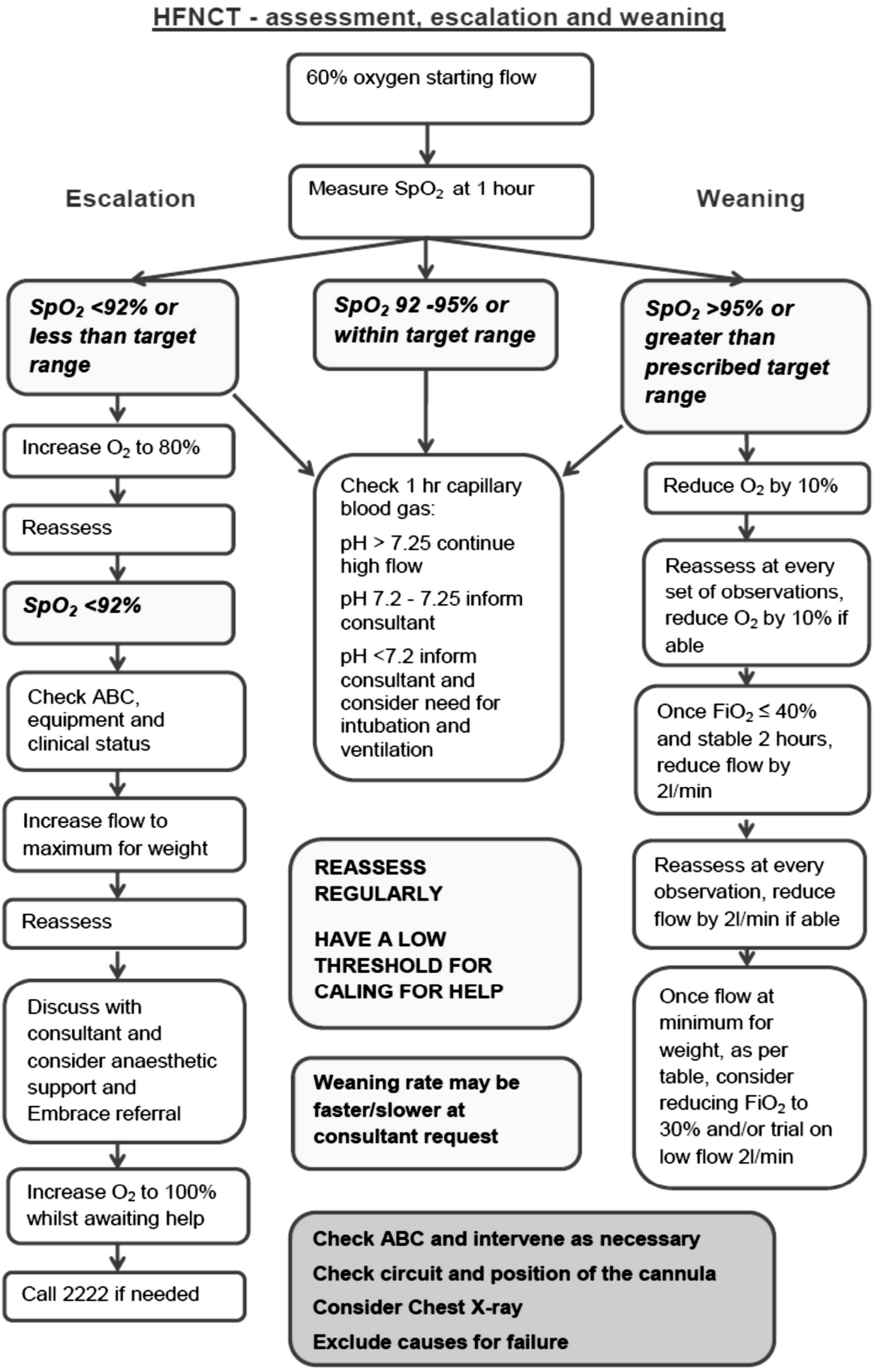
Name: **Age:** **NHS number:** **Location:**

Purpose	An exception report must be completed for any child that has been cared for at a location other than is 'normal' practice to enable a case review to take place following de-escalation. Please refer to Y&H Paediatric Critical care ODN Management of Surge & Escalation Standard Operating Procedure V16 August 23.
Description of exception	
Parties involved in decision.	
Escalation/PCC OPEL Level at time of decision	
Action/Outcome/ Destination	

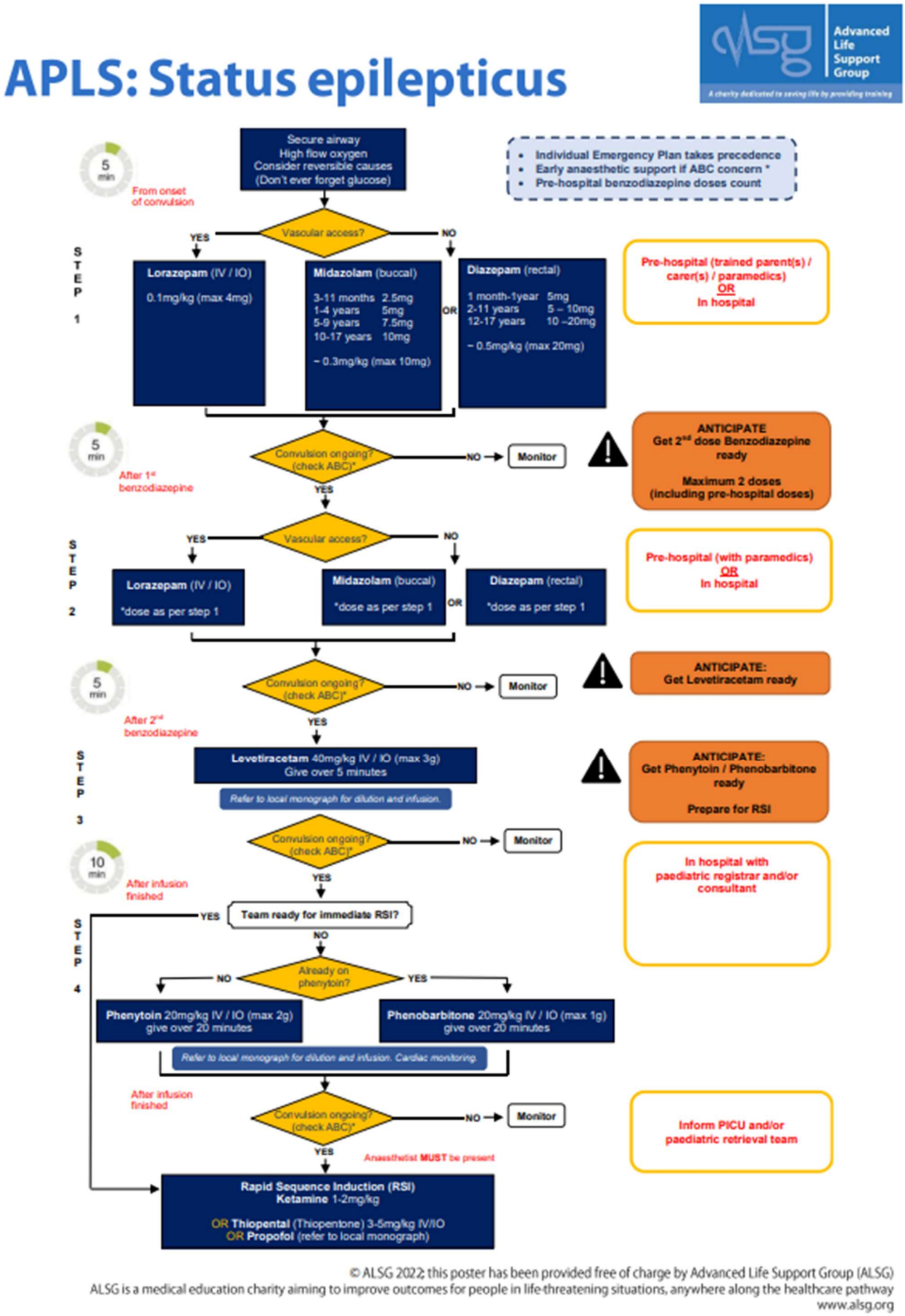
Please return completed form to Jenny Brown Information Support Officer Y&H PCCODN

jennifer.brown38@nhs.net

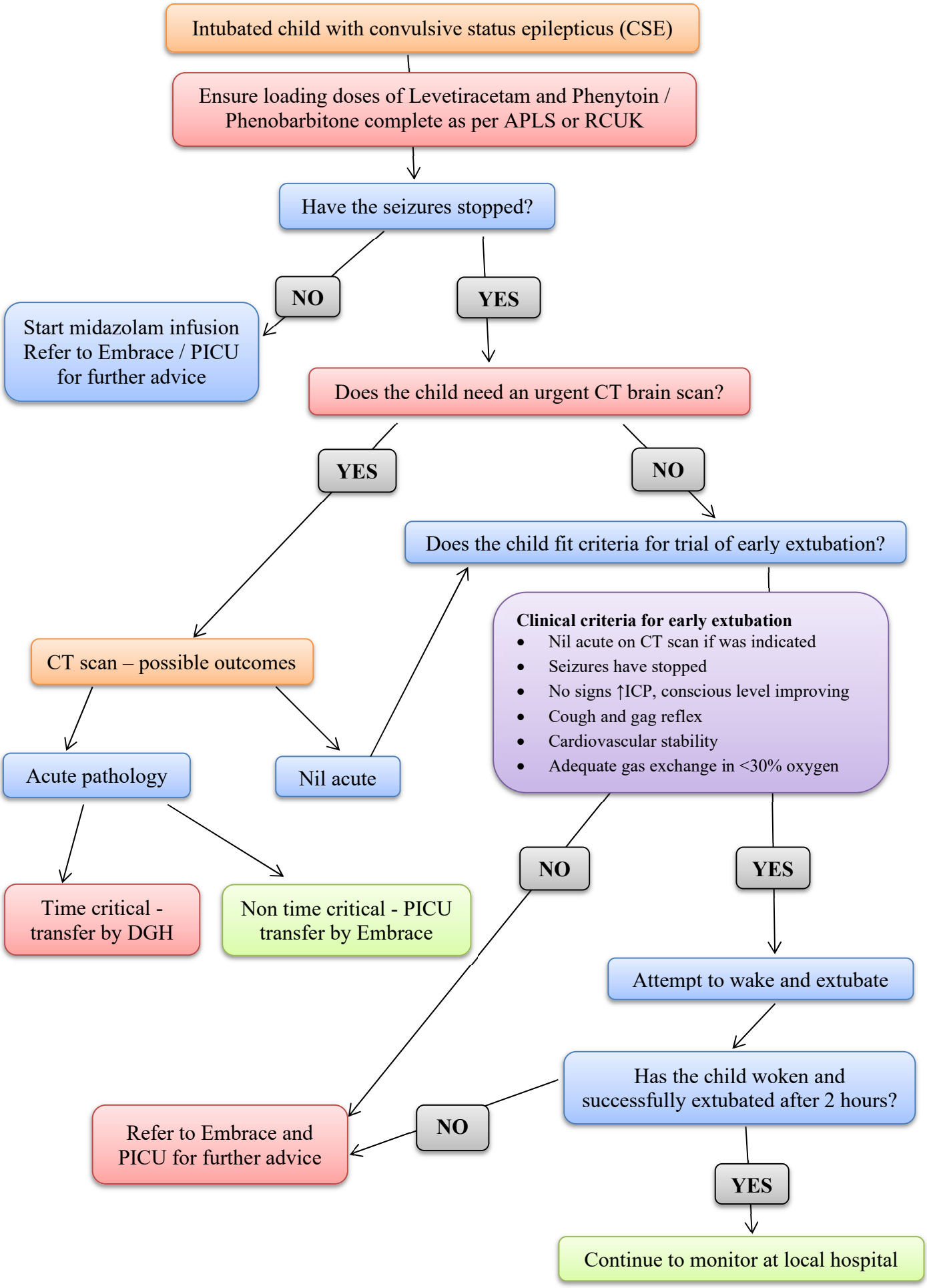
Appendix 2. – High Flow – Assessment, Escalation & Weaning



Appendix 3. – APLS Status Epilepticus Algorithm (Edition 7e, April 2022)



Appendix 4. – Management of the intubated child with consulsive status epilepticus



Useful links

Embrace Yorkshire & Humber Infant and Children's Transport Service

https://www.sheffieldchildrens.nhs.uk/embrace/

Diabetic ketoacidosis

British Society for Paediatric Endocrinology and Diabetes

https://www.bsped.org.uk/about/index.aspx

https://www.bsped.org.uk/media/1959/dka-guidelines.pdf

Management of children with acute decrease in conscious level

Royal College of Paediatrics and Child Health and NICE accredited 2016 (updated 2019)

RCPCH DeCon Poster_R9 A1 updated April 2019.pdf

Metabolic emergencies

British Inherited Metabolic Diseases Group

http://www.bimdg.org.uk/site/guidelines.asp

Poisoning

UK National Poisons Information Service - TOXBASE 0344 892 0111

https://www.toxbase.org/ (username and password needed to access)

Emergency paediatric tracheostomy management

National Tracheostomy Safety Project - paediatric algorithm (review January 2024)

NTSP_Paediatric_Bedhead_signs_templates_to_adapt.pptx (live.com)