OPERATIONAL POLICIES
AND
CLINICAL GUIDELINES
FOR
REFERRAL AND CARE
OF
CRITICALLY ILL CHILDREN
WITHIN
YORKSHIRE AND THE HUMBER
(2013 EDITION)

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Further copies of this document can be downloaded from the above websites.
Introduction

These guidelines have been written to support Network clinicians in the stabilisation of critically ill children and in the referral of these children to the PICUs through Embrace. They are a synthesis of best practice in the region and contain elements of previous documents and guidelines used in Leeds and Sheffield.

This document contains the following:

- A description of the PICU services
- Pathways and contact details for elements of these services
- Clinical guidelines and protocols
  - General guidelines for stabilisation of the critically ill child
  - Specific guidelines for
    - Sepsis
    - Bronchiolitis (including the use of CPAP and HFNCT)
    - Time critical neurosurgical transfers
    - Anaesthetic Management of children with CSE

The guidelines also contain extended sections on respiratory management to form the basis of guidance for a flu pandemic.

From April 1st 2013, the 2 PICUs at the LGI are moving into a combined unit of 20 bed spaces with HDU alongside on D Floor of the Clarendon Wing.
Changes from previous versions

The format is the one used previously and will be familiar to many users. For the benefit of users we have listed changes since the previous guidelines below (May 2010), with major changes in bold:

- The referral pathways (Section 1.2) for emergency neurosurgical admissions into both Leeds and Sheffield includes initial referral of these children to Embrace who will facilitate a conference call.

- Section 1.6: Refusals to PICU admission has been modified to include the rationale for refusal to PIC alongside the caveat that Embrace will locate an available PIC bed.

- There is a new section (1.8 Trauma pathways) describing trauma pathways following the recent major trauma review and phased implementation of Paediatric Major Trauma Networks in the region.

- Section 2.3: Endotracheal intubation has been extended to include advice on cuffed endotracheal tubes.

- There is a separate section (Section 2.7: Duct dependent heart disease) which outlines the regional guideline* on the indications and use of Alprostadil in duct dependent heart disease.

- Section 3.2: Bronchiolitis has been re-written and expanded to contain guidance for the use of high flow nasal oxygen canula therapy alongside CPAP and IPPV.

- Section 3.3: Time critical neurosurgical transfers has replaced ‘Head Injuries’ and outlines the responsibilities of key personnel involved with the management of these children.

- There is a new section (Section 3.4: Anaesthetic management of Status Epilepticus) which is targeted to anaesthetists to promote the safe management of children and to minimise the need for PICU admission.

- There is a one-way time critical transfer checklist in the appendix to support the referring hospital team.

* Written by Dr Yoginder Singh
Description of PICU services in Yorkshire and the Humber

Regional Paediatric Intensive Care services in Yorkshire and the Humber are based on two sites: Leeds and Sheffield. These services are supported by Embrace, the Yorkshire & Humber Infant & Children’s Transport Service.

Leeds Children’s Hospital (at Leeds General Infirmary) has a wide range of paediatric subspecialty interests. The service accepts liver, cardiac and vascular patients for the whole region. There are limited dedicated HDU facilities in Leeds.

Sheffield Children’s Hospital admits all medical and surgical specialities with the exception of cardiology and vascular surgery. The critical care facility has both intensive and high dependency areas.

Hull provides critical care facilities for children admitted through Hull Royal Infirmary and does not accept referrals from outside Hull.

Referrals should follow existing patient flows.

The following specialties should be referred to Leeds or Sheffield:
- General Paediatrics
- Paediatric Surgery
- Neurology and Neurosurgery

In addition, Leeds will accept referrals for:
- Cardiology and Cardiac Surgery
- Vascular emergencies
- Hepato-biliary problems

There are Burns Units in Pinderfields Hospital (Wakefield) and Sheffield Children’s Hospital. The nearest Burns Centre is at the Royal Manchester Children’s Hospital. Referral pathways are described in section 1.5. You can contact Embrace for help with transport, bed location and access to clinical advice for burns patients.

Embrace offers a stand-alone transport service which will take responsibility for bed location and transport of all critically ill children and neonates from hospitals within the relevant networks. The service is independent of the bed capacity in Leeds and Sheffield and will operate even when these units are full. The service has a 24/7 call centre which can arrange call conferences between referring clinicians, the transport team and the accepting unit staff and will involve other specialists as required. The service has been fully operational since September 2010.

We welcome comments and feedback on these guidelines at any time. These guidelines can also be accessed and downloaded at the following websites: www.leedspicu.org, and www.embrace.sch.nhs.uk
Useful telephone numbers

**Embrace**
- Hotline: 0845 147 2472
- General enquiries: 0114 305 3005

**Sheffield Children’s Hospital**
- PICU: 0114 271 7119
- Switchboard: 0114 271 7000

Burns registrar
- Mon - Fri 8-4 via SCH switchboard
- Out-of-hours Northern General Hospital Switchboard (0114 243 4343)

Neurosurgeon
- Via Hallamshire Hospital: 0114 271 1900

**Leeds Children’s Hospital**
- PICU General and Cardiac (ward 47): 0113 392 7447
- Neurosurgeon via switchboard
- Switchboard: 0113 243 2799

**Pinderfields Burns Unit**
- Plastic Surgery registrar: 0844 811 8110

**Manchester Burns Centre**
- 0161 701 8181

**National Burns Bed Bureau**
- 01384 215 576
- Fax: 01384 215 580

**YAS Trauma Co-ordinator**
- 01924 584 927 or 07920 889 265

**YAS Comms**
- 01924 584 954
SECTION 1

OPERATIONAL POLICIES:
1.1 Contacting PICU

For children who need access to Paediatric Critical Care facilities please contact Embrace (0845 147 2472). 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 (esp 9 – 5 Mon –Fri).

<table>
<thead>
<tr>
<th>Embrace</th>
<th>(Yorkshire &amp; Humber Infant &amp; Children’s Transport Service)</th>
</tr>
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<tbody>
<tr>
<td>0845 147 247 2</td>
<td>General enquiries 0114 305 3005</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Leeds PICU</th>
<th>0113 3927447</th>
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</thead>
<tbody>
<tr>
<td>LGI switchboard 0113 2432799</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Sheffield PICU</th>
<th>0114 2717119</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheffield Children’s Hospital Switchboard 0114 2717000</td>
<td></td>
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</table>

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 whom 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) “call co-ordination form” as a template to ensure that you have all the required clinical information available.
1.2 Acute neurosurgical admissions

Time critical neurosurgical problems require one way transfer by the referring hospital team to Leeds or Sheffield. There are well established referral pathways into Leeds and Sheffield. You may choose to use Embrace to help you with the referral process.

Children who have a high probability of requiring neurosurgical intervention will not be refused by either neurosurgical service regardless of the PICU bed state. They will be accepted and then arrangements made for their continuing care after definitive treatment.

Hull does not accept admissions for emergency paediatric neurosurgery.

Leeds

- Resuscitate and stabilise child in referring hospital
- Obtain CT and transfer images
- Consider referral via Embrace (0845 147 247 2)
- Discuss with Neurosurgical team at LGI (Conference call arranged by Embrace)
- Neurosurgeons advise A&E and PICU of imminent neurosurgical transfer
- Neurosurgeons: Accept patient if appropriate
  Give advice on further management
- Child transferred to LGI A&E resus room by referring hospital team
  In A&E: Handover to LGI anaesthesia (or PICU) staff
  Assessment / CT scan / Surgery / PICU as appropriate.

Notes:
- The transfer of all head injuries and other neurosurgical emergencies into Leeds remains the responsibility of the referring hospital.
CAEC Reg ID. No. 1382v3 Paediatric Critical Care Guidelines, Yorkshire and the Humber
- Initial referral of these children is to Embrace who will conference in the neurosurgeon and PIC consultant. It is the responsibility of the neurosurgeon to inform PICU and A & E of the impending arrival of the child.
- Additional advice on the management of the child may be obtained from PICU and Embrace if required.

Sheffield

For transfers into Sheffield, please arrange for CT image transfer to the Royal Hallamshire Hospital, Sheffield, for review by the neurosurgical team. Hard copies or images burnt to CD will need to be sent with the child at transfer or the images can be sent by PACS link to SCH.

For criteria for neurosurgical referral of head injuries and for further advice on the management of head injuries see Section 3.3: Time critical neurosurgical transfer.
1.3. **Acute medical and surgical admissions**

This group comprises all children other than elective admissions and those with acute neurosurgical or newborns with cardiac problems. 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 1.7
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 directly through LGI switchboard (0113 243 2799) or through Embrace (0845 147 247 2).

If the child may require transfer, we suggest that you contact Embrace who will call conference the cardiologist and other appropriate specialists and then organise the bed and transfer with the agreed degree of urgency.

If it is not immediately clear that the child needs transfer, then it may be appropriate to discuss with the cardiologist in the first instance. This can be done either through Embrace or through LGI switchboard. 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.

There are occasional children who require urgent cardiological intervention (usually neonates with transposition of the great arteries). Such children 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 DGH team.
1.5 Burns care

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. 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.

Burn 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 critical care support).
- LGI has a PICU with plastic surgery on site, but no dedicated burns service.
- Manchester has a Children’s Burns Centre.

Burns care pathways are different in the two halves of the region.

To help with the referral process we suggest that you use the common burns documentation which is available from [www.leedspicu.org](http://www.leedspicu.org) and [www.embrace.sch.nhs.uk](http://www.embrace.sch.nhs.uk)

Transfer

Patients requiring PICU or HDU level care should be referred via the Embrace Transport Service (0845 1472472). Transport of patients requiring ward level care in a Burns Unit is the responsibility of the referring hospital team. Embrace will help co-ordinate beds. The National Burn Bed Bureau is another resource [www.nbbb.org.uk](http://www.nbbb.org.uk) Tel: 01384 215 576 Fax: 01384 215 580
In the Southern half of the region (those units that refer PIC patients into Sheffield) burns care is co-ordinated from the Burns Unit at Sheffield Children’s Hospital. The Plastic Surgery Registrar on-call for Sheffield 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).

The SCH Burns Unit will accept all patients with burns up to 30% TBSA intubated or un-intubated. For those children under 1 year of age the threshold is 15% TBSA. Children with more than 30% TBSA burns (>15% if under 1 year of age) will be referred to Manchester Burns Centre (Plastic surgery SHO via 0161 701 8181).

In the Northern half of the region (those units that refer PICU into Leeds) burns care is co-ordinated from the Burns Unit at Pinderfields (via Plastic Surgery Registrar on 0844 811 8110).

The PICU in Leeds will accept children with inhalat ional injury provided that any burn is less than 5% TBSA and does not involve special areas.

Pinderfields will accept children with burns that are not expected to require critical care support, i.e. children less than a year old less than 10% TBSA burn and those over one year of age with less than 15% TBSA burn. Please discuss un-intubated children with burns with the Burns Unit at Pinderfields.

Children in the Northern half of the region who do not meet the criteria for admission locally should be referred to Sheffield Children’s Hospital or Manchester Burns Centre using the criteria documented for the Sheffield area above.
**Child with Burns**

Discuss with Pinderfields Burns Unit via Plastics Surgical Registrar

Intubation?

- **Yes**
  - LGI PICU
  - Minor Burn*
    - Yes
    - Refer to Sheffield area algorithm
    - No

- **No**
  - <10% TBSA and aged under 1 year
    - Or
    - <15% TBSA and aged over 1 year
      - No
      - Yes
  - Pinderfields Burns Unit

*Minor Burns
< 5% TBSA
Not face, hands, feet, perineum, flexures
1.6 Refusals to PICU admission

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

<table>
<thead>
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<th>Refusals to PICU admission</th>
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<tbody>
<tr>
<td>1. Children who are unlikely to benefit from intensive care because their prognosis is so poor as to make admission to PICU inappropriate (RCPCH Withholding and Withdrawing Life Sustaining Treatment in Children).</td>
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<tr>
<td>2. Children whose clinical condition is such that they can be safely managed within the resources available at the referring hospital.</td>
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<td>3. When there are no staffed beds available on the PICU.</td>
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Notes:

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

2. Children refused PICU admission remain the responsibility of the referring clinician.
1.7 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 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 or complicated, if the trainees or ANP’s are inexperienced, or as part of an on-going training programme.

Whilst we make every effort to ensure that trainees are not sent out to collect children beyond their experience, clinical situations may change. If difficulties arise during a retrieval, the Transport Consultant and/or the PICU consultant on call will be contacted for advice and back up. We would also expect that specialists at the referring hospital to continue to support the transport team.

Mobilisation
The team is provided to assist with 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 specially equipped 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 clinician during this period although we will offer advice where appropriate. Continuing communication is encouraged.

Embrace will not normally undertake time critical transfers, and it is vital that DGH’s retain a capacity to transfer critically ill children.
1.8 Trauma pathways

Following the recent trauma review, the Major Trauma Networks began their phased implementation in April 2012. Although primarily based around adult trauma, paediatric trauma has also been included. Paediatric 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.

**Primary transfers**

Children with major trauma will be admitted either to their nearest Trauma Unit (TU) or, as implementation proceeds, may by-pass the TU and come directly to the PMTC.

For example:

If a child is within 45 minutes of PMTC and fulfils prehospital triage, the child should be taken directly to a PMTC.

- Children that arrive at Scunthorpe General Hospital or Diana Princess of Wales Hospital in Grimbsy and are assessed as having major trauma, will be transferred to Sheffield Children’s Hospital.
- Children that arrive at Scarborough General Hospital or York District Hospital, and are assessed as having major trauma will be transferred to Leeds General Infirmary.
- Children that are assessed as having major trauma in Hull will be taken to Hull Royal Infirmary.

- The nearest PMTC to Hull is at Leeds; however Hull Royal Infirmary does have the capability to manage some major trauma in children. Therefore there will be cases where it is deemed clinically more appropriate to remain in Hull.
- The decision as to whether it is better for the child to be transferred to Leeds, rather than managed in Hull, will be based on the PIC matrix criteria and clinical indicators. The decision will be made in discussion with Leeds paediatric specialists through the Embrace call conferencing service.

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

**Secondary transfers**

Paediatric Major Trauma Centres and Combined 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. Children presenting to Trauma Units with major trauma will therefore require transfer to a Major Trauma Centre.

These secondary transfers will usually be to the Network Major Trauma Centre although this may vary if the child has an injury that requires a dedicated specialised pathway.
These specialised paediatric pathways are for:
- Acute interventional radiology
- Acute vascular surgery
- Acute cardiothoracic surgery
- Burns

The core principle of Major Trauma Networks is that the receiving Major Trauma Centre is obliged to accept the patient irrespective of bed availability. In order for the specialised pathways to work within the region this principle must apply across these pathways as well as part of a wider Yorkshire and Humber Trauma Network.

Within Yorkshire and the Humber and the North Trent Networks, Embrace already acts as a single point of contact for advice and specialist transport of infants and children. The new Trauma Networks are building upon this model for children rather than developing a parallel model by using both the call conferencing and transport facilities as required.

Early transfers (e.g. for acute head injuries) should be arranged using the model of transfer shown below. Where the referring hospital is outside the Yorkshire Ambulance Service region, Embrace can still be used to facilitate communication whilst the transfer is organised using the local ambulance provider.

Transfers outside of the immediate post trauma period should be arranged through Embrace in the same way as other retrieval requests.

**Model for transfer – Yorkshire Ambulance Service Region:**

*The MTC may use this pathway for injuries requiring additional input (e.g. burns, thoracic and vascular injuries).
**Once in post*
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

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 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 extreme cases where a child cannot be suitably stabilised, transfer may not be possible.

These procedures are summarised below:

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<tr>
<th><strong>ACCEPT model</strong></th>
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<td><strong>Assessment</strong></td>
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<td><strong>Control</strong></td>
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<td><strong>Communication</strong></td>
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<td><strong>Evaluation</strong></td>
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<td><strong>Preparation</strong></td>
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<td><strong>Packaging</strong></td>
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<tr>
<td><strong>Pre-departure checks</strong></td>
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<td><strong>Transportation</strong></td>
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Copies of notes and radiological investigations (hard copy or CD unless PACS transfer is available) must accompany the patient.
2.1.1. Drug Infusions

The issue of the formulation of drug infusions in paediatrics is unresolved. Children’s services have traditionally used a variable concentration system (i.e. put ‘x’ mg of drug per kg body weight, made up to 50ml). The Department of Health has mandated fixed concentrations for most clinical areas including neonatology. Paediatrics has an exemption at present because multiple fixed concentrations would be required to meet the needs of the paediatric population. The drug calculators for PICU reflect this equivocal position at present.

Sheffield Children’s Hospital uses variable concentrations up to 40kg, whereas Leeds PICU uses variable concentrations up to 16kg and fixed thereafter. The respective drug calculators reflect these differences. Embrace follows the Sheffield formulary. However, if a child is coming to Leeds and the infusions have been made up, prescribed and labelled appropriately, Embrace staff will continue an infusion that has been set up according to “the Leeds recipe”.

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 diluent e.g. made up to 50ml in 0.9% sodium chloride.
- The rate (or range of rates) of administration e.g. 5 to 10microgram/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. Minimum criteria for stabilisation and safe transfer

Wherever possible, children should be stable, have adequate venous access and appropriate monitoring before transfer. Our guidelines on stability and minimum standards are as follows:

**Airway**
- Airway protected by intubation in most cases
- ETT securely fixed
- ETT position confirmed on CXR

**Ventilation**
- Appropriate analgesia, sedation and muscle relaxation
- Ventilation established on transport ventilator
- Adequate gas exchange confirmed by blood gas analysis. Normally:
  - $\text{PaO}_2 > 10 \text{ kPa}$ unless cyanotic heart disease
  - $\text{PaCO}_2$ within acceptable limits for clinical situation

**Circulation**
- Heart rate, BP stable
- Capillary refill < 3 seconds or improving
- Base excess better than -5 or improving
- Any obvious blood loss controlled
- Haemoglobin $> 8 \text{ g/dl} (80 \text{ g/L})$
- Minimum of two routes of appropriately sized venous access
- Arterial line and central venous access are desirable in patients requiring inotropic support
- Central venous access is preferable in those patients who require inotropic / vasopressor support however peripheral solutions may be used where central access cannot be obtained.

**Neurology**
- Seizures controlled, metabolic causes excluded
- Raised intracranial pressure appropriately managed
  - Positioned head up 20 – 30°
  - $\text{PaCO}_2$ 4.5 - 5.0kPa
  - $\text{PaO}_2 > 12kPa$
  - 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
- Full spinal immobilisation
- Pneumothoraces drained
- Intra-abdominal injuries adequately investigated and appropriately managed
- Long bone/pelvic fractures stabilised
- Blood available
- Access major haemorrhage protocol

Exceptions: the above minimum criteria apply in all cases except in time critical transfer when a compromise may be required between speed and full stabilisation

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 cardex
- Referral letter
- Transfer of radiology by PACS (hard copy or CD if PACS transfer not 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.embrace.sch.nhs.uk
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 / 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.

Equipment required

- Endotracheal tube of the correct size, one size smaller and one larger than estimated
- Lubricant for nasal intubation
- Laryngoscope, handle and appropriate size blade
- Suction device, yankeur sucker and relevant size ET suction catheter
- Magill’s forceps
- Oxygen supply
- Bag and mask – appropriate to patient size
- Oropharyngeal airways – appropriate to patient size
- Securing system
- Naso-gastric tube
- Stylet and gum elastic bougie

Selection of endotracheal tubes (ETT)

<table>
<thead>
<tr>
<th>Age</th>
<th>Weight (kg)</th>
<th>Internal diameter (Size)</th>
<th>Length at lip (cm)</th>
<th>Length at nostril (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>newborn</td>
<td>2</td>
<td>3.0</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>newborn</td>
<td>3</td>
<td>3.0</td>
<td>8.5</td>
<td>10.5</td>
</tr>
<tr>
<td>newborn</td>
<td>3.5</td>
<td>3.5</td>
<td>9</td>
<td>11</td>
</tr>
<tr>
<td>3 month</td>
<td>6.0</td>
<td>3.5</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>1 year</td>
<td>10</td>
<td>4.0</td>
<td>11</td>
<td>14</td>
</tr>
</tbody>
</table>
Children aged 1 year and over

Tubes of size less than 6.0 should normally be uncuffed (see below)

**Diameter**

ETT size can be estimated using the following formula:

\[
\text{ET tube diameter in mm} = \frac{\text{Age in years} + 4.0}{4}
\]

Alternatively, the following table provides a ready guide (both are published data but do not produce the same results):

<table>
<thead>
<tr>
<th>Age</th>
<th>Internal diameter (Size)</th>
<th>Oral tube Length at lip (cm)</th>
<th>Nasal tube Length at nostril (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 months</td>
<td>4.0 – 4.5</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>24 months</td>
<td>5.0 – 5.5</td>
<td>14</td>
<td>17</td>
</tr>
<tr>
<td>2 – 4 years</td>
<td>5.5 – 6.0</td>
<td>15</td>
<td>18</td>
</tr>
<tr>
<td>4 – 7 years</td>
<td>6.0 – 6.5</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>7 – 10 years</td>
<td>6.5 – 7.0</td>
<td>17</td>
<td>21</td>
</tr>
<tr>
<td>10 – 12 years</td>
<td>7.0 – 7.5</td>
<td>20</td>
<td>22 - 25</td>
</tr>
</tbody>
</table>

Table adapted from Hazinski

The tube that will fit comfortably through the anterior nares will usually fit the trachea

**Length**

\[
\text{ETT length in cm} = \frac{\text{Age} + 12}{2}
\]

\[
\text{Nasal tube} = \frac{\text{Age} + 15}{2}
\]

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 above are those measured at the lips or the nose.

- These calculations / 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. e.g.

<table>
<thead>
<tr>
<th>Size of ETT</th>
<th>Distance through the cords</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 &amp; 3.5 mm</td>
<td>3.0 cm</td>
</tr>
<tr>
<td>4.0 &amp; 4.5 mm</td>
<td>4.0 cm</td>
</tr>
<tr>
<td>5.0 mm</td>
<td>5.0 cm</td>
</tr>
</tbody>
</table>

- 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 at the body of the 2nd thoracic vertebra.

**Cuffed endotracheal tubes**

Cuffed endotracheal tubes are now available in paediatric sizes and their use in infants and small children is increasing. Concerns about the incidence of subglottis stenosis are unresolved and smaller tubes can be difficult
If a cuffed endotracheal tube is used in a child then:

- A tube of internal diameter 0.5 cm smaller than that expected for the child should be selected.
- There should be an audible leak present before the cuff is inflated
- The cuff should only be inflated if ventilation is inadequate
- If the cuff is inflated, a pressure manometer must be used to ensure safe cuff pressures
- Care must be taken to ensure that
  - The cuff is fully through 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.

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dosage</th>
<th>Administration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propofol</td>
<td>1 – 2 mg/kg</td>
<td>IV</td>
</tr>
<tr>
<td>Ketamine</td>
<td>1 - 2 mg/kg IV (or 5 – 10mg/kg IM)</td>
<td>IV or IM</td>
</tr>
<tr>
<td>Thiopentone</td>
<td>1- 5 mg/kg</td>
<td>IV</td>
</tr>
<tr>
<td>Midazolam</td>
<td>0.1 – 0.3 mg / kg</td>
<td>IV</td>
</tr>
<tr>
<td>Suxamethonium</td>
<td>1 - 3 mg / kg *</td>
<td>IV</td>
</tr>
<tr>
<td>Atracurium</td>
<td>0.5 – 1.0 mg / kg</td>
<td>IV</td>
</tr>
<tr>
<td>Vecuronium</td>
<td>0.1mg/kg</td>
<td>IV</td>
</tr>
<tr>
<td>Rocuronium</td>
<td>0.6 - 0.9 mg/kg</td>
<td>IV</td>
</tr>
<tr>
<td>Atropine</td>
<td>20 micrograms / kg (minimum effective dose 100 micrograms, maximum dose 600 micrograms)</td>
<td>IV</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>0.9%</td>
<td>Flush</td>
</tr>
</tbody>
</table>

* Neonates 3mg / kg, Infants 2mg / kg, older children 1mg / kg.

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 (anaesthetic) 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 and adrenaline prepared in appropriate doses

Potential contraindications to rapid sequence induction

- Anticipated difficult intubation e.g. congenital or acquired airway abnormalities.
Contra-Indications to suxamethonium

<table>
<thead>
<tr>
<th>Contra-Indications to suxamethonium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent burns or crush injuries*</td>
</tr>
<tr>
<td>Neurological deficit (e.g. spinal injury)*</td>
</tr>
<tr>
<td>Renal failure with a raised serum potassium</td>
</tr>
<tr>
<td>Severe hepatic failure</td>
</tr>
<tr>
<td>Hyperkalaemia</td>
</tr>
<tr>
<td>Myasthenia gravis</td>
</tr>
<tr>
<td>Myotonia</td>
</tr>
<tr>
<td>Muscular dystrophy</td>
</tr>
<tr>
<td>History of malignant hyperthermia</td>
</tr>
<tr>
<td>History of cholinesterase deficiency</td>
</tr>
</tbody>
</table>

*Suxamethonium is not contraindicated within the first 24 hours of injury

Atropine should always be given with suxamethonium to help protect against critical bradycardia.

Recommended procedure for intubation

Orotracheal intubation is performed in the first instance to secure the airway. Naso-tracheal tubes are more easily secured for transit. 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

- Pre-oxygenate, for 3 minutes, with 100% oxygen via a high flow breathing system.
- Administer anaesthetic.
- Apply cricoid pressure.
- 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
  - Watching chest movement
  - Auscultation of the chest (axillae) and stomach
End tidal carbon dioxide monitoring – we use capnography or disposable EtCO$_2$ sensors to confirm ET tube placement on PICU.

- Secure the ET tube, suction secretions (oropharyngeal and endotracheal). Connect to ventilator and ventilate the patient with oxygen and pass a nasogastric 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.

- Maintain cricoid pressure.
- 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 one once the patient has been stabilised if there are no contra-indications. It is acceptable to manage patients exclusively with an oral tube.

Nasal tubes have several advantages. They:

- Are easier to secure
- Cause less stimulation so they are tolerated at lower levels of sedation
- Move less and may thus cause less trauma to the airway.

Adequate sedation and paralysis should be given before changing from an oral to a nasal ETT.

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 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. Cuffed tubes are not used routinely at sizes less than 6.0.
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 $\text{SpO}_2$ and give you some “breathing space”. **Children should not be transferred with a pack insitu.**

**Fixation**

There are lots of ways of doing this. We tend to use a “double trouser leg” technique, with pads of stomahesive across the cheeks to protect the skin. 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

Compliance
Circuits need to have a low compliance (usually also low volume). 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\textsubscript{2} sampling cuvettes. The smaller the child, the greater the concern. With infants it may be necessary to place filters at the machine end of the circuit. Some anaesthetic machines are unsuitable for ventilating small children if the side-stream gas sampling device is used.

Infection control
On ICU bacterial filters/HMEs placed between the circuit and the patient can impair the effectiveness of humidifiers and increase apparatus dead space. If using a transport ventilator or anaesthetic machine then consider placing them at the machine end of the circuit when treating small children (because of dead space considerations).

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.
Simple volume controlled ventilators (e.g. ventipac) require particular care in small children to ensure that the volumes delivered are not excessive.

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\textsubscript{2}O. 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 cmH₂O. 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 cmH₂O and go up to pressures of 10 - 15 cmH₂O 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, register the tidal volume if possible (this should be 6-8 ml/kg), check EtCO₂ and adjust the ventilator in response until you have achieved normal-looking chest movement/tidal volume. Then adjust the rate to achieve the desired CO₂.

Monitoring

SpO₂
Continuous SpO₂ monitoring with appropriate alarms is mandatory for any ventilated child. Running SpO₂ at 92-95% in children ventilated for respiratory failure allows staff to respond appropriately to improvements in the child’s condition.
EtCO₂
Side-stream CO₂ 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 EtCO₂ readings.

Blood gases
Although arterial catheters are often used, the technical difficulties of inserting them means that many children ventilated for respiratory failure are 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. PaO₂ is meaningless in venous or capillary gases, normal pCO₂ is approximately 0.5 kPa higher and pH is slightly lower than an arterial sample.

Adjustment of ventilator settings

When considering targets for CO₂ and O₂ 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 CO₂ 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 are adults. In children ventilated for respiratory failure, we often choose to allow CO₂ to rise to 8-10 kPa provided that the pH remains above 7.25. We also allow O₂ saturations to fall to 90% if the child is proving hard to ventilate rather than increase inflation pressures above 28-30 cmH₂O and/or FiO₂ above 0.8.

Oxygenation

In general, although SpO₂ can be improved by increasing FiO₂, this does not address the underlying pathological problem causing the shunt. If SpO₂ has fallen below 90%, then FiO₂ 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 FiO₂ to maintain SpO₂ 92-95%.

Ventilation (CO₂)

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 CO₂ 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 (increase expiratory time [Te] on most neonatal ventilators).

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 RMB?
  - 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. Fluid management

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:** Initial maintenance fluids can normally be provided as:

| Neonates day 1 | Glucose 10% |
| Neonates after day1 | Glucose 10% + electrolyte additives as required |
| Infants and children | Glucose 5% + Sodium chloride 0.45% + Potassium chloride 0.15% (10 mmol potassium in 500 ml)* |

*Other fluids may be suggested by the PICU consultant depending upon age and underlying diagnosis (e.g. 0.9% Sodium Chloride in children with head injury).

<table>
<thead>
<tr>
<th>Typical requirements are as shown in the table:</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Term neonates</strong></td>
</tr>
<tr>
<td>Day 1</td>
</tr>
<tr>
<td>Day 2</td>
</tr>
<tr>
<td>Day 3</td>
</tr>
<tr>
<td>Day 4+</td>
</tr>
<tr>
<td><strong>1 to 6 months</strong></td>
</tr>
<tr>
<td><strong>6 months upwards</strong></td>
</tr>
<tr>
<td>(5 - 50 kg)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>(50 ml / kg / day for the 2nd 10 kg)</td>
</tr>
<tr>
<td>(20 ml / kg / day for each additional kg.)</td>
</tr>
<tr>
<td>&gt; 65 kg</td>
</tr>
</tbody>
</table>

**Note:**
Outside the immediate neonatal period Glucose in Sodium Chloride 0.18% is not recommended for maintenance fluid. This solution may result in hyponatraemia, which has caused a number of deaths.

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

\[
\text{Volume} = \text{weight (kg)} \times 1000 \text{ ml} \times \% \text{ dehydration} / 100
\]

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

**Continuing losses,** for example gastric contents from NG tubes should be replaced ml for ml with sodium chloride 0.9% ± potassium.
Fluid resuscitation for shock

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

- Give boluses of 20 mls/kg sodium chloride 0.9% or colloid. Reassess (pulses, blood pressure, capillary refill, urine output) and repeat as necessary.

- In trauma, initial boluses should be 10mls/kg of 0.9% sodium chloride

- The use of colloid is not recommended in traumatic brain injury.

- Volumes in excess of 100 mls/kg may be required in sepsis. In these circumstances significant haemodilution (and/or dilutional coagulopathy) may occur.

- Check haemoglobin and clotting and consider the need for transfusion of blood products following the first 40ml/kg.

- When volumes in excess of 40 mls/kg are required, the use of inotropes and ventilatory support and discussion with PICU should also be considered. (See inotropes below.)

- The use of sodium chloride 0.9% or Human Albumin Solution in large volumes will result in a hyperchloreaemic 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), tranexamic acid and Fresh Frozen Plasma / Platelets according to you local major transfusion protocols.
2.6. Inotropes and other vasoactive drugs

Indications

- Inotropes are indicated in any circumstance where cardiovascular insufficiency (e.g. poor tissue perfusion, hypotension) persists despite initial resuscitation.

- Inotropes should be considered in any situation where volumes of fluid > 40 mls/kg have 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 20 mls/kg 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. The choice of agent will depend upon the clinical situation:
  - If the mean arterial blood pressure is reasonably maintained and the principle concern is poor perfusion, add an inodilator agent e.g; dobutamine (5 - 20 micrograms/kg/min) or inopressor e.g; dopamine (5 -10 micrograms/kg/min).
  - If the mean arterial blood pressure is also low, then add an inopressor agent e.g. adrenaline (0.1 - 1 microgram / kg / min) or dopamine (10 - 20 microgram/kg/min).

NB Dobutamine and dopamine can be safely given via a peripheral cannula*

Adrenaline can also be given through a peripheral cannula if absolutely necessary but a dilute solution should be used and the site observed carefully for extravasation. All inotropes and vasoactive drugs can be given via an IO needle at the concentrations use for central venous delivery.

*For peripheral use, dobutamine concentration should be < 5mg/ml, dopamine solution should be < 3mg/ml

- If the preload and cardiac output are adequate (pink warm peripheries, good capillary refill time) but the patient remains hypotensive, then a vasopressor agent should be added.
  - Noradrenaline (0.1 - 1 microgram/kg/min) is the agent of choice.

Whenever an agent is started the patient should be reassessed frequently. If there is no improvement, it may be appropriate to start an additional agent. For example, if there is no response to dobutamine, adrenaline may be added to improve cardiac output. If the blood pressure remains low despite adrenaline, add noradrenaline.

Patients unresponsive to fluids and inotropes

In those patients who fail to respond to ‘normal doses’ of inotrope reassess and consider:

- Sodium bicarbonate to correct pH if < 7.15

- Calcium infusion if ionised calcium < 1 mmol/L (standard calcium < 2..2)

- Steroids in septicaemic shock (Neonates: IV hydrocortisone 2.5mg/kg qds , Child >1month: 1mg/kg QDS)

- Vasopressin
2.7. Duct dependent heart disease

In neonates who fail to respond to initial resuscitation measures consider duct dependent heart disease. Start prostoglandin infusion and discuss with paediatric cardiologists at the LGI.

**Use of Alprostadil in duct dependent congenital heart conditions**

- **Antenatally diagnosed Transposition of Great Arteries (TGA) / duct dependent condition or cyanosed infant who is well and non-acidotic**
- **Infants with absent femoral pulses but otherwise well and non-acidotic**
- **Acidotic / unwell infants with suspected duct dependent congenital heart conditions**

Manage Airway Breathing and Circulation as per APLS guideline for sick infant. Sepsis, respiratory or metabolic conditions can mimic similar clinical presentation or can be associated with duct dependent conditions - treat these conditions if any clinical suspicion! Acidotic / unwell infants usually need mechanical ventilation for severe hypoxaemia, acidosis or cardio-respiratory failure.

**DO NOT DELAY STARTING ALPROSTADIL WHICH CAN BE GIVEN PERIPHERALLY OR CENTRALLY (IV or IO)**

- **Start Alprostadil 12.5 nanograms/kg/min**
  - Discuss with paediatric cardiologist
  - Aim for oxygen saturations between 75 – 85% (if cyanosed) or palpable femoral pulses
  - Double the dose after every 20 min if no improvement in oxygen saturation or femoral pulses and discuss with paediatric cardiologist.

- **Start Alprostadil 25 nanograms/kg/min**
  - Discuss with paediatric cardiologist

- **Start Alprostadil 100 nanograms/kg/min**
  - Discuss with paediatric cardiologist urgently via Embrace
  - Aim for oxygen saturations between 75 – 85% (if cyanosed) or palpable femoral pulses
  - Consider correcting metabolic acidosis
  - Further discussion with paediatric cardiologist for urgent transfer or advice via Embrace.

**Time critical emergency:** Consider time critical emergency if oxygen saturations do not increase above 70% or no improvement in acidosis or lactate levels despite 100 nanogram/kg/min of Alprostadil

**Calling Embrace on 08451472472** at an early stage to allow discussion of transport options is strongly recommended.
Prescription and administration of Alprostadil

**Always prescribe as ALPROSTADIL.** Never prescribe as prostaglandin E1 or Prostin.

**The continuous infusion should NOT be stopped.** An infant on Alprostadil should have two routes of intravenous access. One for Alprostadil and the other as spare or other IV infusions.

**Alprostadil (Prostin VR):** Ampoule presentation 500 micrograms in 1 ml

**Standard Alprostadil Infusion:** 300 microgram made up to 50 mls (final concentration). This equates to 6000 nanograms /ml

**To make this up:**
Take 0.6 ml of Alprostadil (Prostin VR) ampoule and transfer to syringe containing 49.4 ml of suitable diluent (see below). Mix well.

**Suitable diluents:**
- Sodium chloride 0.9%
- Glucose 5%
- Glucose 10%

**Stability of prepared infusion:** Each syringe will be stable for 24 hours

**Continuous infusion:** Can be given peripherally or centrally / intraosseously

**Compatibility:**
Wherever possible Alprostadil should be given via a dedicated line.

Local experience has suggested that Alprostadil can be given with other infusions (e.g. dobutamine, dopamine and morphine) where there is limited IV access.

**Dose range:**
10 – 200 nanograms/kg/min  COMMENT cBNF top dose is 100 nanograms / kg / min

Using Alprostadil standard solution of 300 micrograms in 50ml (This contains 6000 nanograms per ml)

- **12.5 nanograms/kg/minute = Run @ 0.125 ml/kg/hr**
- **25 nanograms/kg/minute = Run @ 0.25 ml/kg/hr**
- **100 nanograms/kg/minute = Run @ 1 ml/kg/hr**

Example
A 3kg baby requiring an alprostadil infusion to start at 25 nanograms/kg/min

= 3kg x 0.25ml/kg/hr = 0.75 mls/hour
2.8. 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 paralysed patients is difficult. Physiological parameters such as heart rate and blood pressure, particularly in response to 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 alfentanil 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.
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.

**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 retrieval.
- To facilitate the safe transfer of intubated / ventilated patients.
- To prevent rises in intracranial pressure (associated with coughing etc.) in patients with brain injury or cerebral oedema.
- 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.
- Ensure the patient has adequate sedation/analgesia before muscle relaxation
SECTION 3

CLINICAL GUIDELINES

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 (BNF), paediatric formularies and hospital pharmacist.
3.1 Sepsis

**Diagnosis and assessment**

Systemic Inflammatory Response (SIRS)
- Temperature (above 38.0) or hypothermia (below 36)
- Tachycardia (or bradycardia in infants)
- Initially vasodilatation
- Tachypnoea is often also seen.

Shock (SIRS + evidence of organ failure)
Evidence of organ failure is any of:
- Altered mental status
- Signs of warm shock
  - Bounding pulses
  - Rapid capillary refill
  - Wide pulse pressure
  - Warm peripheries
- Signs of cold shock
  - Diminished pulses
  - Capillary refill time more than 2 seconds
  - Narrow pulse pressure
  - Cold, mottled peripheries
- Urine output less than 1 ml/kg/hr
- Hypotension (late sign)

**Treatment**

Early, aggressive and appropriate management improves survival.

The following lab findings support the diagnosis:
- Base excess -8 or worse
- Serum lactate greater than 4
- Coagulopathy

Features of severe disease include:
- Extensive or rapidly spreading rash
- Hypotension
- Low WCC
- Thrombocytopenia
- Coagulopathy

**Initial bloods:**
- FBC
- CRP
- Coagulation studies
- U & E, calcium, magnesium
- Glucose
- Blood for culture and PCR
- Blood gas (arterial, capillary or venous)
- Group and cross match
  - Red cells
  - FFP
  - Platelets

*Do not perform lumbar puncture*
Immediate management (1st 5 minutes)

- Ensure patent airway
- Ensure adequate respiration
  - Give high flow oxygen
  - Intubate and ventilate if necessary
- Obtain venous access (IV or IO)
- Obtain blood samples
- Ensure antibiotics have been administered

Early management (1st 15 minutes)

- Give 20 mls/kg fluid (sodium chloride 0.9%, HAS or colloid) over less than 10 min.
- Correct hypoglycaemia and hypocalcaemia
- Reassess against therapeutic endpoints and repeat fluid bolus (20 mls/kg) if necessary

Intermediate management (1st hour)

- Discuss with PICU
- Consider intubation and ventilation
- Give further bolus of fluid
- Start dopamine (in warm shock) or dobutamine (in cold shock) infusion (5 – 15 micrograms/kg/min)
- Obtain central venous and arterial access
- Continue fluid boluses (up to 200mls/kg may be needed in first hour)
- Add either
  - Adrenaline infusion (0.1 – 1 microgram/kg/min) for cold shock or
  - Noradrenaline infusion (0.1 – 1 microgram/kg/min) for warm shock
- Consider giving sodium bicarbonate if pH remains below 7.15
- Consider steroids (1mg/kg hydrocortisone, 2.5mg/kg in neonates) if inotropic requirements are escalating
- Exclude other causes (pericardial effusion, pneumothorax, ongoing blood loss, intracranial event)
- Vasopressin 0.0003 – 0.002 units/kg/min
- All inotropes can be given through an IO line.
- With care adrenaline can be infused through a peripheral line as a dilute solution.

Indications for intubation

Induction of anaesthesia and institution of IPPV may cause cardiovascular collapse.

- Depressed conscious level
- Respiratory failure
- 40 – 60 mls/kg volume resuscitation
- Cardiovascular collapse

To minimise the risk of cardiovascular collapse:

- Ensure the presence of the most experienced anaesthetist available
Pre-oxygenate (> 3min ideally)

Continue volume resuscitation

Continue inotropes

Prepare further 20 mls/kg bolus(es) of fluid and adrenaline boluses at appropriate dilution

Rapid sequence intubation with ketamine 1- 2 mg/kg + suxamethonium 1– 3 mg/kg or rocuronium 0.6 – 0.9 mg/kg

Atropine should always be given with suxamethonium to help protect against critical bradycardia.

Management after intubation

Sedate and paralyse (midazolam ± morphine + muscle relaxant of choice)

Ventilate at tidal volume ($V_t$) 5 - 7 ml/kg

Normal PaCO$_2$ (4.5 – 5.5 kPa) if possible with normal $V_t$

May unmask pulmonary oedema

- Suction
- Ventilate with high PEEP (up to 15 cmH$_2$O)
- Continue volume resuscitation if necessary

**Raised intracranial pressure (ICP)**

Signs of raised ICP

- Decreased or fluctuating level of consciousness
- Hypertension and relative bradycardia
- Unequal, dilated or poorly reacting pupils
- Focal neurological signs
- Abnormal posturing, hyperreflexia or seizures
- Papilloedema

Treatment of raised ICP

- Treat ABC and shock if present
- Give osmotherapy (sodium chloride 2.7% or 3% 2-3 ml/kg or mannitol 0.25g/kg over 20 minutes)
- Steroids (dexamethasone 0.4 mg/kg bd for 2 days)
- Intubate and ventilate to PaCO$_2$ 4.5 – 5.0 kPa
Flow Chart for Acute Management of Sepsis

1. Recognise impaired mental status and tissue perfusion
   Maintain airway and establish venous access

2. 20 mls/kg boluses of fluid up to 60 mls/kg
   Correct hypoglycaemia and hypocalcaemia

3. Fluid responsive shock

4. Fluid refractory shock
   Consider intubation, discuss with PICU
   Start peripheral inotropes (dopamine or dobutamine)
   Establish central venous and arterial access/monitoring
   Observe in HDU environment

5. Fluid refractory dopamine / dobutamine resistant shock

6. Fluid refractory shock
   Adrenaline infusion for cold shock
   Nor-adrenaline infusion for warm shock

7. Catecholamine resistant shock
   Exclude other causes of shock
   • Pericardial effusion
   • Pneumothorax
   • Ongoing blood loss
   • Intra-cranial event
   Consider:
   • Steroids
   • Bicarbonate if pH < 7.15
   • Vasopressin 0.0003 – 0.002 units/kg/min

Adapted from Surviving Sepsis International Consensus Guideline 2010
3.2. Bronchiolitis

The incidence of severe bronchiolitis is higher in babies with the following problems:

- Prematurity
- Chronic lung disease
- Congenital heart disease
- Immune deficiency (most commonly Down’s Syndrome)
- Atopy

Most infants with bronchiolitis will recover with simple supportive measures. A small proportion clearly require intubation and ventilation at presentation or at subsequent review.

Non-invasive respiratory support may reduce the frequency with which these infants require ventilation. Two modes are readily available:

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

Early studies suggest that HFNCT may be as effective as CPAP whilst being simpler to administer.

Units that are unable to deliver CPAP/HFNCT are encouraged to discuss those children who meet criteria for their use with Embrace/PICU.

Figure 1. Flow chart of respiratory support for Infants with Bronchiolitis
Indications for referral to PICU include the following:

- Hypoxaemia
- Exhaustion leading to hypercarbia
- Respiratory failure (mixed pattern)
- Apnoeas unresponsive to CPAP or HFNCT
- Septicaemic picture with cardiovascular collapse
- Failure of CPAP or HFNCT
- An inability (staff, equipment or capacity) to deliver NCPAP or HFNCT in a baby for whom it is indicated.
- Significant co-morbidity

Indications for the use of HFNCT or CPAP

Consider additional respiratory support with HFNCT or CPAP if two or more of the following are present:

- Respiratory rate > 60 breaths/min
- Apnoeas, bradypnoea or cyanotic episodes (with or without bradycardia) despite supplemental O₂
- Severe intercostal recession and indrawing
- Need for > 2 L/min O₂ via nasal prongs or 60% headbox O₂
- PaCO₂ 8.5 kPa or more (in children without pre-existing chronic lung disease)
- Rising PaCO₂ (> 2 kPa from baseline)
- Respiratory acidosis (pH 7.2 – 7.28, if pH < 7.20 consider ventilation)

Contraindications to the use of HFNCT and CPAP

- The need for intubation and/or mechanical ventilation as evidenced by the presence of:
  - Severe cardiovascular instability and impending arrest
  - pH < 7.20
  - SpO₂ < 88% in maximal oxygen therapy
- Upper airway abnormalities that may make HFNCT, NCPAP, or Nasal Mask (NM) CPAP ineffective or potentially dangerous (e.g. choanal atresia, cleft palate or tracheoesophageal fistula)
- Pneumothorax
- Inadequate staffing (numbers and expertise) or equipment to deliver and monitor safely (see below)

High Flow Nasal Cannula Oxygen Therapy (HFNCT)

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 >2 l/min. 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
- Reduction in metabolic work associated with heating and humidification of gas
- Provision of mild distending pressures

‘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.’

Advantages

- More comfortable, with less risk of nasal trauma than with CPAP
- Easier to use than CPAP, not dependent on seal
- Easier access to child than CPAP and head box oxygen
- Easier parent 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)

Set up

HFNCT is applied to infants 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.

HFNCT is approved for the delivery of gas by nasal cannulae at flow rates up to 8L/min in infants and 40L/min in adults.

- **Nasal cannulae should not occlude >50% of the child’s nares**
- The mouth should not be held closed
- Set the initial flow rate using the table below.
- Pass nasogastric or oro-gastric tube and leave on free drainage. Aspirate tube 4 hourly.

Management

- Start with $\text{FiO}_2$ 0.6 (60%) and a relatively high flow – age related. (See table below).
- Set target $\text{SpO}_2$ for child (normally 92 -95%) may need to be lower in children with chronic lung disease or congenital heart disease.
Monitoring

- Continuous HR and SpO\textsubscript{2} monitoring
- Half hourly recording of observations (RR, HR, SpO\textsubscript{2}) for the first 2 hours
- Hourly recording after 2 hours if patient is improving
- Fluid balance
- Daily U&E if on IV fluids
- Blood gases
  - Check a capillary gas before starting HFNCOT
  - If pH < 7.20 – consider ventilation
  - pH 7.20 – 7.25 – start HFNCOT. Observe closely. Repeat gas within 1 hour
  - pH > 7.25 and getting better clinically on HFNCOT – no need to repeat gas.

Assessment

If SpO\textsubscript{2} > 95%

- Reduce FiO\textsubscript{2} in 10% increments until SpO\textsubscript{2} 92 – 95% (or target) or FiO\textsubscript{2}
- If following reduction in FiO\textsubscript{2}, SpO\textsubscript{2} remains > 95% reduce flow by 10-20% increments until SpO\textsubscript{2} 92 -95% of flow rates below age appropriate thresholds.
- If SpO\textsubscript{2} remains > 95% HFNCOT can probably be discontinued (unless it was started for apnoeas or airway obstruction)
- If a child initially required high flow rates, once they are stable, continued need can be tested by reducing flow rate by 10% every 12 hours

If SpO\textsubscript{2} < 92%

- Increase FiO\textsubscript{2} to 80%
- If following increase in FiO\textsubscript{2} SpO\textsubscript{2} remains < 92%, increase flow by 20-25%.
- If SpO\textsubscript{2} is still < 92%, increase flow again until maximum flow rate achieved. If still no improvement increase FiO\textsubscript{2} to 100% Exclude causes for failure – nasal obstruction, pneumothorax, gastric distension leading to diaphragmatic splinting and then call PICU.
- Once SpO\textsubscript{2} rise to more than 95% maintain high flow and reduce FiO\textsubscript{2} until SpO\textsubscript{2} 92 -95%
- If maximum flow rate is reached or temporarily exceeded, consider need for CPAP or intubation

<table>
<thead>
<tr>
<th>Age</th>
<th>Min flow rates l/min</th>
<th>Starting flow rates</th>
<th>Max flow rate</th>
<th>Cannula size</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 4 months</td>
<td>5</td>
<td>6</td>
<td>8</td>
<td>Infant</td>
</tr>
<tr>
<td>4 - 6 months</td>
<td>6</td>
<td>9</td>
<td>12</td>
<td>Paediatric - small</td>
</tr>
<tr>
<td>7 - 12 months</td>
<td>8</td>
<td>12</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>1 - 4 yrs</td>
<td>10</td>
<td>15</td>
<td>20</td>
<td></td>
</tr>
</tbody>
</table>
If Infant condition stabilises with the above measures of FiO2 >60% or increased flow discuss with Consultant and PICU.

Success of treatment can be gauged by:
- Reduction in frequency/severity of apnoea
- Reduction in oxygen requirement
- Reduction in heart rate and respiratory rate (evidence suggests possible within first 90 minutes)
- Improvement in respiratory acidosis
- Reduction in work of breathing

Failure of treatment can be gauged by:
- Persistent apnoeas
- Increasing oxygen requirement
- Unchanged/rising heart rate and respiratory rate
- Failure to improve respiratory acidosis
- An unchanged or increased work of breathing
- SpO$_2$< 92% at FiO$_2$ > 60% and maximal age-appropriate flow rate

If HFNCT is failing:
- Check circuit and nasal cannulae position
- Consider change to CPAP
- Repeat chest X-ray
- Review diagnosis
- Consultant review (Paediatrician and/or Anaesthetist / Intensivist)
- Review need for IPPV

Discontinuation
- Need for IPPV
- Intractable gastric distention and diaphragmatic splinting
- Improvement, therefore able to wean
- If no progress by day 3 (48 - 72 hours):
  - Discuss with PICU
  - Review diagnosis/ co-morbidity
  - Consider IPPV

Weaning
Therapy is weaned if the infant's condition improves and there are no clinically significant apnoeas for 12 hrs:
- Once a child is on HFNCT FiO2 should be reduced before flow
- Reduce FiO$_2$ to keep SpO$_2$ 92-95%
• Only when FiO₂ is less than 0.4 (40%), and the child is stable, flow rate can be reduced by increments of approximately 10-20% every 12-24 hours as tolerated (this may be reduced more quickly if indicated)
• Once FiO₂ is 30%, and flow rate is at or below minimum age appropriate value then consider changing to low flow oxygen therapy

Potential complications of HFNCT therapy to consider
• Sudden deterioration requiring immediate ventilation
• Potential barotrauma leading to surgical emphysema / pneumothoraces, especially if cannulae occupy more than 50% of the diameter of the nares.
• Aspiration
• Gastric distention and diaphragmatic splinting
• Obstruction or irritation due to improper sizing of nasal cannulae

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 (with airway manometer) and masks of appropriate size
• Gastric tube for periodic decompression of stomach

HFNCT can be used in Paediatric units where:
• Nursing staffing levels are adequate to ensure initial close observation
• 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

Continuous Positive Airway Pressure (CPAP)

Set up
Continuous positive airway pressure can be applied to infants by:
• Nasal prongs (NCPAP)
• Infant nasal mask (NM-CPAP)
• Nasopharyngeal short ETT tube

These are administered with a commercially available circuit used in conjunction with a continuous flow source, infant ventilator, or a suitably equipped multipurpose ventilator

• CPAP is usually applied at a pressure of 6 cmH₂O initially at FiO₂ 0.6. Once applied:
  • If SpO₂ > 95% reduce FiO₂ to keep SpO₂ 92 -95%
  • If SpO₂ < 92% adjust FiO₂ to keep SpO₂ 92-95 (to maximum FiO₂ of 80%)
  • If FiO₂ > 0.6 increase CPAP by 2 cm H₂O increments to a maximum of 10cmH₂O
CAEC Reg ID. No. 1382v3 Paediatric Critical Care Guidelines, Yorkshire and the Humber

- If SpO₂ remains < 92%
  - (Re) X-ray (to exclude barotrauma)
  - Check efficacy of CPAP (see below)
  - Consider ventilation
- Pass nasogastric or orogastric tube and leave on free drainage.
  - Aspirate tube 4 hourly

**Potential complications of CPAP therapy**

- Sudden deterioration requiring immediate ventilation
- Barotrauma leading to surgical emphysema / pneumothoraces
- Increased intrathoracic pressure causing reduced venous return and lower cardiac output (may necessitate one or more fluid boluses)
- Aspiration
- Gastric distention and diaphragmatic splinting
- Hypercarbia as a result of increased apparatus dead space
- Mouth breathing which may result in loss of desired pressure and decrease in delivered oxygen concentration
- Patient discomfort/ agitation / intolerance of mask
- Facial sores/ nasal erosion
- Sustained high FiO₂ (eg >0.8) may cause alveolar collapse due to loss of nitrogen splinting

**Monitoring**

- Continuous HR, RR and SpO₂ monitoring
- Half hourly recording of observations for the first 4 hours
- Hourly recording after 4 hours if patient is improving
- Repeat blood gas measurement within 1 hour
- Fluid balance
- Daily U&E if on IV fluids

**Assessment**

**Success of treatment can be gauged by:**

- Reduction in frequency/ severity of apnoea
- Reduction in oxygen requirement
- Reduction in heart rate and respiratory rate
- Improvement in respiratory acidosis
- Reduction in work of breathing

**Failure of treatment can be gauged by:**

- Persistent apnoeas
- Increasing oxygen requirement
- Unchanged/ rising heart rate and respiratory rate
If CPAP is failing:
- Check circuit and seal
  - Check position and size of nasal device (prong or mask)
  - Check circuit for leaks
  - Leak through mouth (dummy may help)
- Consider increasing CPAP pressure
- Repeat chest X-ray
- Review diagnosis
- Consultant review (Paediatrician and Anaesthetist / Intensivist)
- Review need for IPPV

Discontinuation
- Need for IPPV
- Intractable gastric distention and diaphragmatic splinting (rare)
- Improvement, therefore able to wean
- If no progress at 48 - 72 hours:
  - Discuss with PICU
  - Review diagnosis/ co-morbidity
  - Consider IPPV

Weaning
Therapy is weaned if the infant’s condition improves and there are no clinically significant apnoeas for 12 hrs
- Reduce FiO₂ to keep SpO₂ 92-95%
- Once FiO₂ less than 0.4 (40%) reduce CPAP pressure in increments to 4 cmH₂O
- Trial off CPAP and consider changing to HFNCT or low flow O₂ therapy.

Equipment and personnel requirements
- Commercially available nasal prongs, nasal masks or naso-pharyngeal tube with accompanying harness and accessories
- Continuous flow air & oxygen gas source
- Delivery device:
  - Commercially available continuous-flow infant ventilators equipped with CPAP mode, or
  - CPAP flow driver, or
  - Bubble circuit
  - Lightweight CPAP or ventilator circuits with servo-regulated humidification system
- Continuous pulse oximeter
- Continuous electrocardiographic and respiratory rate monitor, with high and low alarm capabilities
Suction source, suction regulator, and suction catheters

Resuscitation apparatus (with airway manometer) and masks of appropriate size

- Gastric tube for periodic decompression of stomach
- Chest drains should be available
- Continuous transcutaneous CO₂ monitoring is optional

**CPAP should only be used in units where:**

- Nurse staffing levels are adequate to ensure a minimum nurse: patient ratio of 0.5:1 while a child is on CPAP
- Nursing staff have received training and are competent to care for patients with CPAP
- Adequate medical staff cover exists to ensure frequent review of patients on CPAP
- The anaesthetic department has been informed that CPAP is being performed and has agreed to support its implementation.

**Other Management Considerations for HFNCT and CPAP**

**Fluid management / feeding**

- Stop feeds initially
- Give IV fluids and restrict intake to 80% of estimated maintenance requirements using sodium chloride 0.45%/glucose 5% with 10 mmol potassium chloride per 500 mL. Check blood sugar or BM regularly. Increase glucose concentration if hypoglycaemic.
- Daily U&Es whilst on IV fluids
- If stable for 4 - 6hrs and still requiring HFNCT or CPAP, consider continuous naso-gastric feeds
- Observe infant for signs of stomach distention and/or non-absorption of feeds

**Sepsis**

- Treat any presumed secondary bacterial infection
  - Take blood culture and throat swab/ NPA
  - Start antibiotics if indicated - IV Cefuroxime or follow local policy

**Sedation**

- Should not be necessary
- Is contraindicated in an unstable infant
- May improve tolerance of CPAP
- Can be hazardous
- Discuss with Consultant (Chloral hydrate 15-30mg/kg may be appropriate)

**Intermitted positive pressure ventilation (IPPV)**

**Airway / Breathing**

- Intubate and ventilate
- Ensure correct ET tube size. Too small a tube will make it difficult to suction secretions and a large leak will compromise ventilation
- Moderate hypercarbia as long as the pH is > 7.25. A PaCO₂ of 8 kPa, or more in children with chronic lung disease, is usually acceptable and helps to avoid increased peak pressures and barotrauma
- Physiotherapy and suction are usually required to remove copious secretions
- Inhaled ipratropium bromide (Atrovent) delivered via a spacer / aerochamber / nebuliser into the breathing circuit may reduce bronchospasm associated with physiotherapy

**Circulation on IPPV**
- Moderate dehydration is common due to the effects of reduced intake and increased insensible losses
- Fluid resuscitation may be required. Give fluid boluses of 10 – 20 ml / kg until circulatory stability is achieved
- Inotropic support may be required if after fluid resuscitation there is continued evidence of hypotension and poor perfusion. Dobutamine or dopamine are suitable agents
- Once cardiovascular stability has been achieved commence 80% maintenance with Sodium Chloride 0.45% / Glucose 5% with 10 mmol potassium chloride per 500mL. U&Es need to be checked regularly.
- Adequate fluid input should maintain urine output of 1 – 2 mls/kg/hr
- Site NG tube
- Start feeds once cardiovascular stability has been achieved

**Antibiotics**
- Broad-spectrum antibiotics (e.g. cefuroxime) are frequently prescribed initially
- Antibiotics should be stopped as soon as bacterial infection has been excluded

**Sedation**
- Intravenous midazolam and morphine and muscle relaxant (e.g. atracurium) are appropriate in the first instance
- Once the child’s condition is stable sedation and / or the continuing need for muscle relaxation can be reassessed
3.3 Time critical neurosurgical transfers

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
- 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 dependant

Communication:
- Leeds: Contact neurosurgeons either directly (LGI Switchboard) or through Embrace
- Sheffield: Contact neurosurgeons through Embrace

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:

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
- C-spine protection for all trauma patients
- 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
- Identify and treat life threatening chest trauma

Circulation and haemorrhage control:
- 2 patent well secured IV lines
- Identify and treat life threatening haemorrhage
- Control ongoing blood loss especially scalp lacerations, fractures intra-abdominal trauma.
- Maintain arterial blood pressure to provide adequate Cerebral Perfusion Pressure (CPP) note post CT the following minimum pressures may need to be higher to accommodate a rising ICP

<table>
<thead>
<tr>
<th>Age (in years)</th>
<th>MAP (mmHg)</th>
<th>Systolic (mmHg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1</td>
<td>&gt; 55</td>
<td>&gt; 70</td>
</tr>
<tr>
<td>2-5</td>
<td>&gt; 60</td>
<td>&gt; 80</td>
</tr>
<tr>
<td>6-12</td>
<td>&gt; 70</td>
<td>&gt; 90</td>
</tr>
<tr>
<td>&gt;12</td>
<td>&gt; 80</td>
<td>&gt; 100</td>
</tr>
</tbody>
</table>

- Ensure adequate circulating volume and use noradrenaline as required
- Noradrenaline can be given via an IO needle
- Do NOT delay 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 sodium chloride 2.7% or 3% 3-5 mls/kg over 20 minutes. This is a short term temporising measure. (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.

Fluids
• Except in children below 6 months, maintenance fluids should be given as sodium chloride 0.9% (hyperglycaemia exacerbates brain injury)
• Monitor blood sugar hourly and give dextrose containing solutions if the blood sugar falls below 4 mmol/L.

Exposure
• Complete primary and secondary survey – treat any life threatening injuries
• Consider trauma to the thoracic and lumber spine and immobilise appropriately
• Maintain normothermia
• Maintain normal blood sugar
• 2/3$^{rd}$ restricted maintenance fluid 0.9% sodium chloride +/- glucose

Preparation and packaging
• Secure on ambulance trolley with appropriate harness
• Elevate head end to 30 degrees if no actual or potential spinal injury
• Check oxygen and use ambulance oxygen for 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 PICU and telephone number

Pre-departure and on route:
• Inform destination PICU 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 PICU and/or neurosurgeon if deterioration
3.4 Anaesthetic management of children with convulsive status epilepticus (CSE).

Aims of this guideline

This guideline is for anaesthetists 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.

An algorithm based on 2012 NICE guidelines is shown in Fig 1. Step 1 & 2 may occur pre-hospital.

Figure 1: NICE Clinical Guideline 137 January 2012

0 minutes
Step 1
- Check ABC
- High Flow Oxygen if available
- Check blood glucose

5 minutes
Step 2
- Midazolam 0.5 mg/kg buccally or
- Lorazepam 0.1 mg/kg iv

15 minutes
Step 3
- Lorazepam 0.1 mg/kg iv
- Start to prepare phenytoin for step 4
- Call for senior help

25 minutes
Step 4
- Phenytoin 20mg/kg iv over 20 minutes or
- Phenobarbital 20mg/kg iv over 5 min (if on phenytoin)
- ± paraldehyde pr
- Inform anaesthesia/ICU

45 minutes
Step 5
- RSI thiopentone 4mg/kg iv or midazolam 0.1 mg/kg or propofol 2mg/kg
- Follow anaesthesia guideline

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

- Reducing the incidence of intubation secondary to respiratory depression
Preventing unnecessary intubation
Identifying those children who can be safely extubated 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. 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 the fit has gone on for, the more difficult it is to stop.

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 as a result 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, propofol\(^1\) or midazolam) as an anticonvulsants.
- 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 a laryngeal mask airway (if tolerated and child starved). 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 Fig. 2

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\(^1\) 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
Many children who are intubated during an episode of CSE can be safely managed in the DGH.

Figure 2. Algorithm for the intubated child with CSE

CT scan indications
Scans will be required by many, if not the majority, of children who have presented with CSE.

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

- There have not been any more fits
- Conscious level is improving (and GCS > 8)
- Adequate cough and gag reflexes
- Cardiovascular stability
- Adequate gas exchange (Sp0₂ > 95% in air)
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 1 hour post seizure
History of trauma
Suspicion of non accidental head injury

CT scan

- Some postictal children are stable and will remain still enough for a CT scan of the head to be performed without further sedation.
- If an LMA has been placed to support the airway, then it may be used for continued anaesthesia.
- Those that require anaesthesia will require substantially reduced doses of induction agents (thiopentone or propofol) as they will already have 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 the need for PICU. The suggested anaesthetic management options are described in Fig. 3

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 (RTI or aspiration)
- Titrated anaesthesia/sedation (propofol/volatile anaesthetic agent)
- Maintenance fluid infusion
- Close observation for further fits
- Maintenance of normal body temperature (consider antipyretics)
- Monitoring & documentation
  - To anaesthetic standards
  - Pupils
  - Conscious level (GCS) after a decision to attempt to wake up
  - Blood glucose
Exubation criteria

- There have not been any more fits
- Conscious level is improving (and GCS > 8)
- Adequate cough and gag reflexes.
- Cardiovascular stability.
- Adequate gas exchange (SpO₂ > 95% in air).

Failure can be gauged by:

- The child is not making reasonable progress (may take 1-2 hours)
- If the fits start again

Seek advice from Embrace & PICU consultant
Appendix 1

Preparing a paediatric patient for a time critical one-way transfer by the referring hospital team

The transport medicine environment is challenging particularly for time critical transfers. For transfers to occur safely your patient may need interventions that would not be performed if the patient remained in your hospital. To minimise the time needed to prepare the patient for transport, please consider the following check list.

Remember to always involve Embrace from the time of seeking specialist advice in order to facilitate the most efficient and appropriate transfer for your patient.

Documentation and communication

☐ Update the parents on the child’s condition and the plans for transfer.
☐ Photocopies of recent relevant notes, recent investigation results, drug chart.*
☐ Highlight/document any social concerns.*
☐ Transfer radiology by PACS (CD or hard copy are alternatives).
☐ Maternal blood sample fully labelled (infants under 3months). *
  - First name
  - Last name
  - Date of birth
  - NHS number
  - Date & time of sample
  - Name and signature of person taking sample

Patient preparation

☐ Maintenance fluids and all other infusions must be in 50ml fully labelled syringes.
☐ Pupillary responses monitored and recorded regularly.
☐ Seizures controlled and metabolic causes excluded.
☐ Maintain temperature above 36.5 °C (unless therapeutically cooled).
☐ Adequate patient monitoring for transport – ECG, BP, SaO2, ETCO2, Temp.
☐ Patient and equipment adequately secured for transport.
☐ Ensure emergency airway, breathing equipment and adequately filled gas cylinders are available.
☐ Ensure emergency fluids and drugs are available for transport.

For further information or assistance please call Embrace to speak directly to a Transport Consultant

0845 147 2472