

OPERATIONAL POLICIES

AND

CLINICAL GUIDELINES

FOR

REFERRAL AND CARE

OF

CRITICALLY ILL CHILDREN

WITHIN

YORKSHIRE AND THE HUMBER

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May 2010



Contents

	Page
Introduction	5
Changes from previous versions	6
Description of PICU services	7
Useful Numbers	8
Section 1	
Operational Policies	
1.1. Contacting PICU	11
1.2. Acute Neurosurgical admissions	12
1.3. Acute Medical & Surgical admissions	14
1.4. Cardiological referral	15
1.5. Refusal policy	16
1.6. Retrieval procedures and policy	17
1.7 Burns	18
Section 2	
Preparing the child for retrieval	23
Note about drug infusions	
2.1. Procedures at the referring hospital	24
2.2. Minimum criteria for safe transfer	25
2.3. Endotracheal intubation	28
2.4. Ventilation	33
2.5. Fluids management	37
2.6. Inotropes	39
2.7. Sedation, analgesia & relaxation	41
Section 3	
Clinical Protocols	
3.1. Sepsis	45
3.2. Bronchiolitis	49
3.3. Head Injury	55
3.4. Cervical spine injury	57
Links	
Leeds documentation, parent information and drug calculator	www.leedspicu.org
Sheffield documentation, parent information and drug calculator	www.criticalcarenetwork.sch.nhs.uk
Embrace Transport Service, referral guidelines and paperwork	www.embrace.sch.nhs.uk
Burns referral document	Any of the above websites
Further copies of this document can be downloaded from the above websites.	

Introduction

These guidelines have been written to support the implementation of the Embrace Yorkshire and the Humber Infant and Childrens Transport Service. They are a synthesis of best practice in the region and contain elements of previous documents and guidelines in use in Leeds and Sheffield.

The documents contain 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)
 - Head injuries (and management of cervical spine injury)

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

Changes from previous versions

The format is the one used by the Leeds service in the past and will be familiar to many users. Those sections updated since June 2009 are highlighted in **bold**.

For the benefit of those users we have listed most of the changes below:

- **A section explaining the policy regarding drug infusions set up by referring hospitals before the arrival of the transfer team.**
- **This version of the guidelines contains a description of the Yorkshire and the Humber Infant and Children's Transport Service (*Embrace*) and it's contact details. The development of this service is reflected in the various other referral pathways.**
- There are contact numbers and referral pathways for both general PICU and emergency neurosurgical admissions into both Leeds and Sheffield.
- **Hull no longer accepts paediatric referrals (including neurosurgery) from other centres.**
- **The cardiology referrals include a statement that Leeds will accept time critical transfers regardless of bed state.**
- **There is a new section describing pathways for children with Burns.**
- There is a new section (2.1) 'Procedures at the referring hospital'.
- The 'Minimum criteria for safe transport' (2.2) includes a caveat that demands the use of clinical judgement as to the balance between full stabilisation and urgency for time critical transfers.
- Section 2.3 on 'Endotracheal intubation' has been extended and modified to include advice on failed intubation, dealing with leaks and fixation of tubes.
- Section 2.4 'Ventilation' has also been substantially re-written to include more detailed information on management of the ventilated patient.
- The section on 'Inotropes' (2.6) has been reduced in size and no longer recommends dobutamine exclusively as a first line inotrope.
- **Section 3.1 'Sepsis' no longer concentrates exclusively on meningococcal sepsis and reflects the 2007 international consensus guidelines.**
- The section on bronchiolitis has been re-written and contains guidelines for the use of CPAP.
- The most important changes in the section on head injuries relate to the addition of 2.7% or 3% sodium chloride as an alternative to mannitol as an osmotic diuretic.
- The recommendations for radiology of the cervical spine follow NICE guidelines.

Description of PICU services in Yorkshire and the Humber

Paediatric Intensive Care services in Yorkshire and the Humber are based on three sites: Leeds, Sheffield and Hull. These services are supported by *Embrace*, the Yorkshire and Humber Infant and Children's Transport Service.

Leeds Children's Hospital (at LGI) has a wide range of paediatric subspecialty interests supported by up to 17 PICU beds. The service accepts liver, cardiac and vascular patients for the whole region. There are limited dedicated HDU facilities in Leeds.

Sheffield admits all medical and surgical specialities with the exception of cardiology and vascular surgery. The paediatric critical care unit has 11 intensive care and 8 high dependency care beds.

Hull provides PICU facilities for children admitted through Hull Royal Infirmary in up to two beds located on the adult ICU. There are also 6 dedicated paediatric HDU beds. Neither facility accepts referrals from outside Hull.

Referrals should initially follow existing patterns.

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 facilities in Pinderfields Hospital (Wakefield) and Sheffield Children's Hospital. The nearest Burn Service is at the Royal Manchester Children's Hospital. Referral pathways are described in section 1.7. 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 usually be able to operate even when those 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 will have a phased implementation starting in December 2009 and expects to be fully operational by October 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, www.criticalcarenetwork.sch.nhs.uk and www.embrace.sch.nhs.uk

Useful Phone 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 Teaching Hospitals

To refer patients or to speak to a Consultant either ring *Embrace* or Ward 2

General PICU (ward 2)	0113 392 7102
	0113 392 6795
Cardiac PICU (ward 4)	0113 392 7104
Switchboard	0113 243 2799

Pinderfields

Plastic Surgery registrar	0844 811 8110
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Manchester Burns service	0161 701 8181
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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.
- Find a bed for your patient. Normally this will follow established referral patterns, but when the local units are full *Embrace* will find the nearest suitable bed.
- Transfer your patient

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.

Embrace
(Yorkshire and the Humber Infant and Children's Transport Service)
0845 147 247 2
General enquiries 0114 305 3005

Leeds PICU
0113 3927102 or 3926795
LGI switchboard 0113 2432799

Sheffield PICU
0114 2717119
Sheffield Children's Hospital Switchboard
0114 2717000

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 appropriateness of intervention.

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

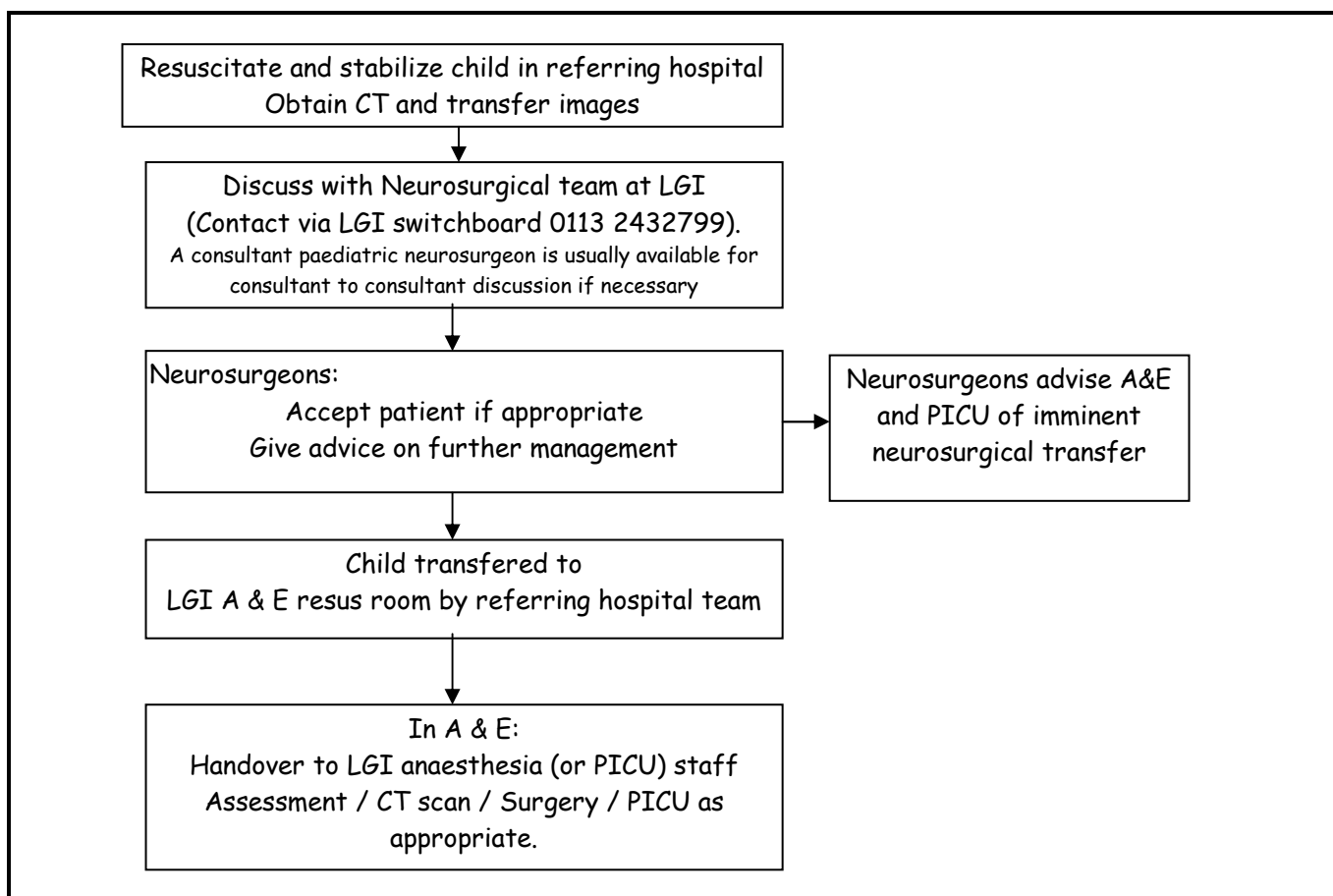
1.2 Acute neurosurgical admissions

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 chose 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.

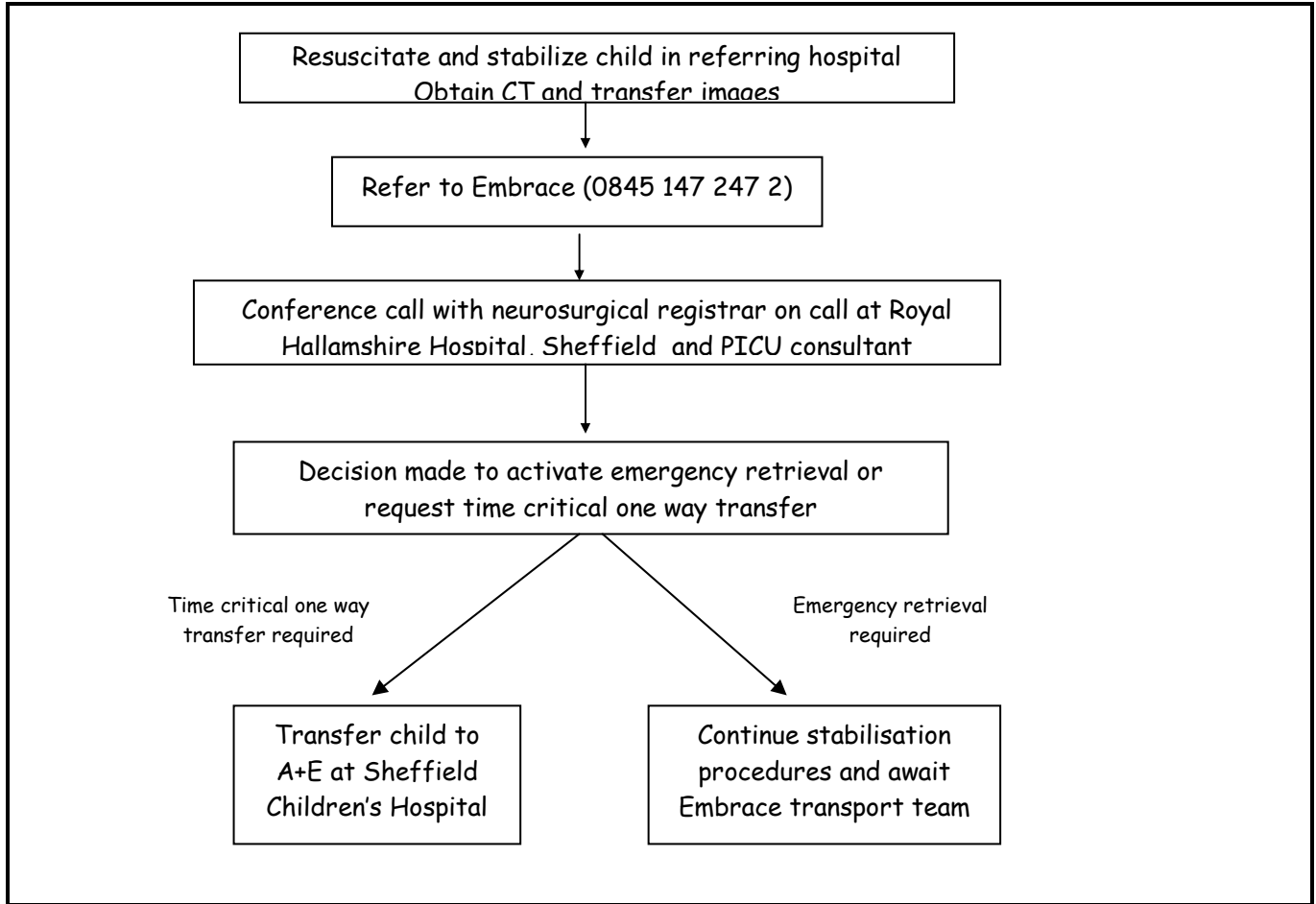
Leeds



Notes:

- Initial referral of these children is to the neurosurgeon. 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 if required.
- Transfer of all head injuries and other neurosurgical emergencies remain the the responsibility of the referring hospital. This will be reviewed once *Embrace* has been operating for a while.

Sheffield



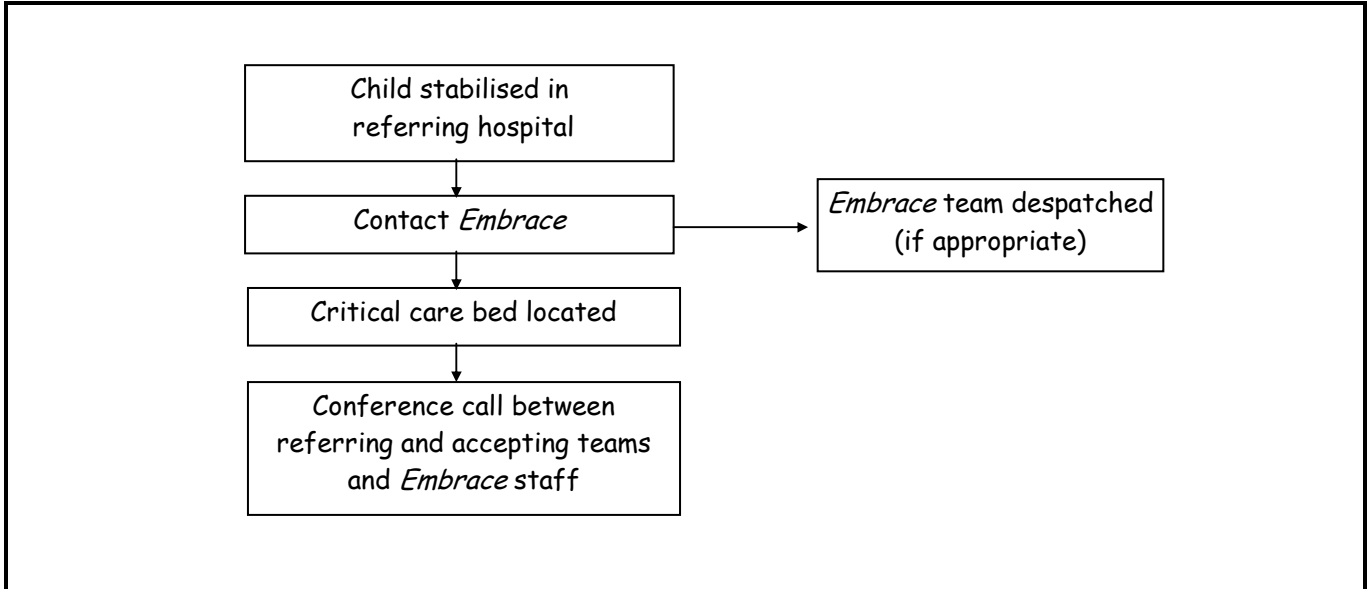
Notes:

- 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 4.3

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 retrieval process see section 1.8

1.4 Cardiology referrals

The Cardiologists in Leeds are available to provide advice on management and the need for - and urgency of - transfer at all times. They can either be contacted directly through LGI switchboard (0113 243 2799) or through *Embrace*. (0845 147 247 2)

If it is possible that the child requires transfer, we suggest that you contact *Embrace* who will call conference the cardiologist and other appropriate specialists and then organise the bed and the 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 requires transfer, then you will need to involve them 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 should be performed by the DGH team.***

1.5 Refusal policy

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

Refusal policy

1. Children who are unlikely to benefit from intensive care^{*1} may be refused admission.
2. Children who are likely to benefit from intensive care may be refused admission if there are no beds available or no nurses available to staff beds
3. Those children who are refused admission to PICU remain the responsibility of the referring clinicians, although we will give telephone advice and support in as far as is possible.
4. *Embrace* will attempt to find an intensive care bed and, when a bed is located, provide a transport team .

^{*1} This may include those children whose condition has improved sufficiently that they can be safely managed in general ward areas and those children whose prognosis is so poor as to make admission to PICU futile.

1.6 Retrieval policy and procedures.

We prefer to collect children who have been referred to PICU whenever possible. (Acute neurosurgical admissions and other time critical admissions excluded - see section 1.2).

Embrace is the Yorkshire and the Humber Infant and Children's Transport Service which is becoming operational over the period from December 2009 to October 2010. Once fully operational the service will provide up to 2 medical teams 24/7 and an additional nurse based team during the day, to facilitate all neonatal transfers and transfers of critically ill children from any hospital in the network to an appropriate critical care bed. The service will also transport children being discharged from PICU to their local hospitals.

Embrace will not, even when fully operational, undertake time critical transfers, and it is vital that DGH's retain some capacity to transfer critically ill children.

Structure of the transport team

Each retrieval is supported by a Consultant with training and skills in Transport Medicine.

Many of the retrievals are performed by appropriately trained middle grade staff. 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 the patients are unstable or complicated, if the trainees 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, we would expect the trainee to contact the Transport Consultant and/or the PICU consultant on call for advice and back up. **We would also expect that specialists at the referring hospital support the transport registrar.**

Mobilisation.

The retrieval team is provided to assist with the safe transport of patients and is not a primary resuscitation service. We recognize the difficulties that may be encountered managing a sick child outside a specially equipped area. We therefore aim to have the retrieval team mobile within 20 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.

1.7 Burns care

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

- Age less than 6 months
- Any burn with evidence of non-accidental injury (also refer to local paediatric team)
- Burn of any thickness to special areas – face, hands, feet, perineum, flexures
- Any circumferential burn
- Partial thickness burn of more than 1% Total Body Surface Area (TBSA)
- Significant inhalational burn
- Chemical, radiation or high voltage electrical burns
- Any burn that has not healed at 10 days

Facilities

- 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 Burns Service.

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, www.criticalcarenetwork.sch.nhs.uk and www.embrace.sch.nhs.uk

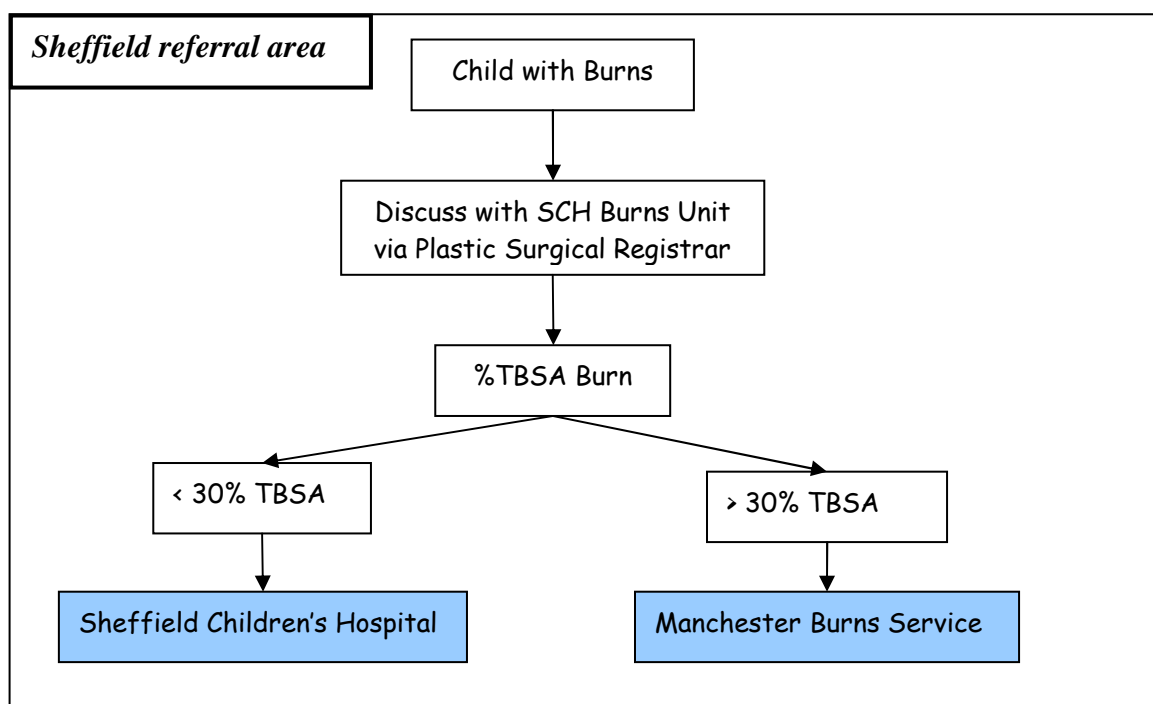
Transfer

Patients requiring PICU level care should be referred via the Embrace Transport Service (0845 147 247 2).

Transport of patients requiring ward level care in a Burns Unit is the responsibility of the referring hospital team.

In the Southern half of the region (those units that refer PICU into Sheffield) burns care is co-ordinated from the Burns Unit at Sheffield Children 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. Children with more than 30% TBSA burns will be referred to Manchester Burns Service (Plastic surgery SHO via 0161 701 8181)

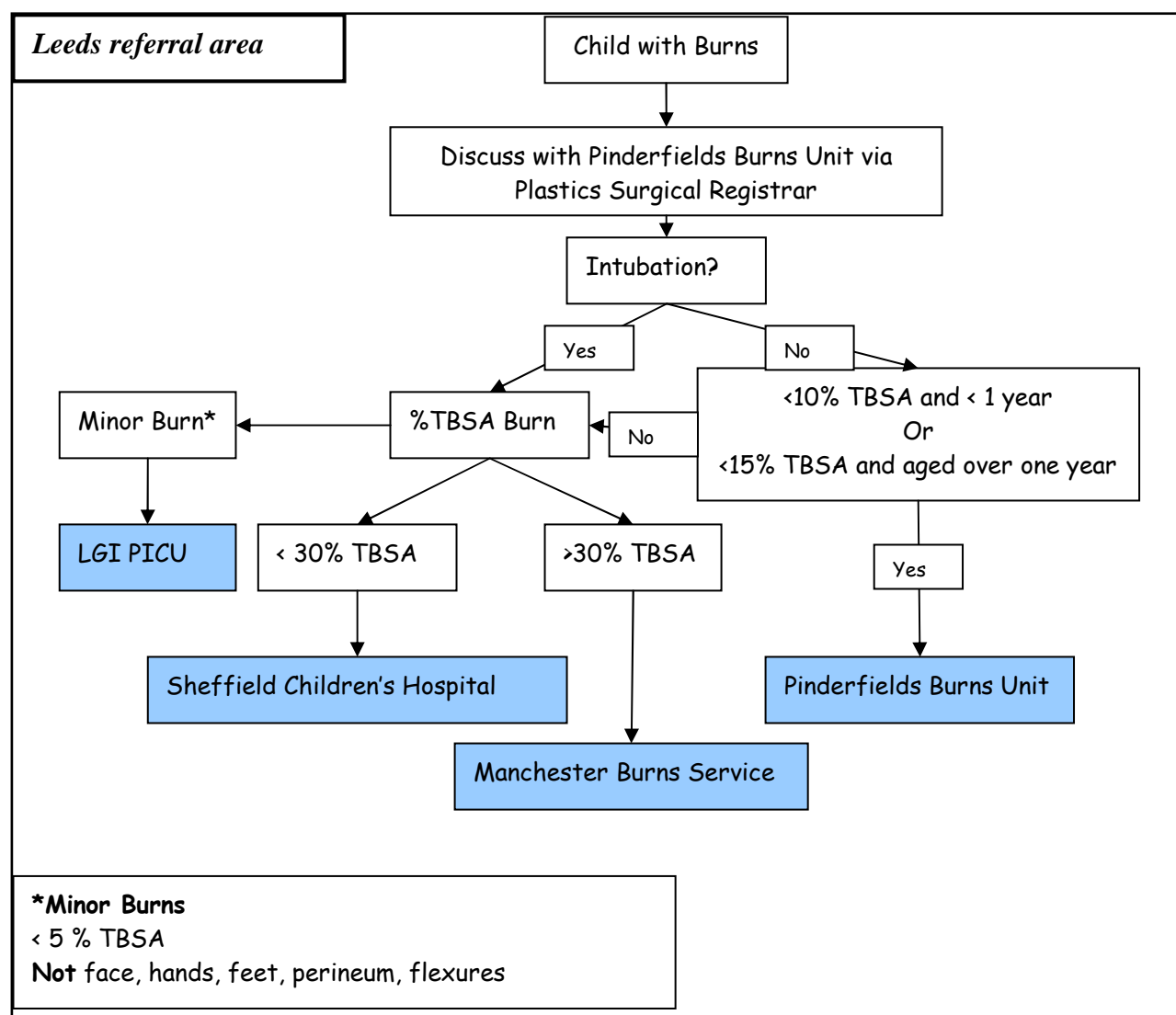


In the Northern half of the region (those units that refer PICU into Leeds) burns care is co-ordinated from the Burns Unit at Pinderfields (via Plastic Surgery Registrar on 0844 811 8110)

The PICU in Leeds will accept children with inhalational 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 with 10% burn or less 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 (burns up to 30% TBSA, intubated or un-intubated) or Manchester Burns Service (all burns over 30% TBSA).



SECTION 2

PREPARING THE CHILD FOR RETRIEVAL

Note:

Information provided on use of drugs and recommended doses reflect the current practice on the PICU. 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.

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 a number of 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 50kg, whereas Leeds PICU uses variable concentrations up to 16kg and fixed thereafter. The respective drug calculators reflect these differences. *Embrace* will follow the Sheffield formulary by default. 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% saline.*
- 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.

Please use the drug calculator for the relevant receiving unit and take care with prescription and syringe labelling.

2.1. Procedures at the referring hospital

On arrival at the referring hospital 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

ACCEPT model	
A ssessment -	Handover What has been done? What needs to be done?
C ontrol -	Team leader to delegate required tasks
C ommunication -	Professionals Parents Documentation
E valuation -	Is transfer still appropriate?
P reparation -	ABC approach
P ackaging	
P re-departure checks	
T ransportation	

Copies of notes and radiological investigations (hard copy, CD or PACS transfer) must accompany the patient

2.2. Minimum criteria for safe transport

Before transfer, children should be stable, have adequate venous access and appropriate monitoring. 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
 - 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 $> 8 \text{ g/dl}$
- Minimum of two routes of venous access
- Arterial line and central venous access are desirable in unstable patients
- Central venous access is required in those patients who require inotropic / vasopressor support or where other routes of vascular access cannot be obtained.

Neurology

- Seizures controlled, metabolic causes excluded
- Raised intracranial pressure appropriately managed
 - Positioned head up $20 - 30^\circ$
 - PaCO_2 $4.5 - 5.0 \text{ kPa}$
 - $\text{PaO}_2 > 12 \text{ kPa}$
 - 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-thoracic and intra-abdominal bleeding controlled
- Intra-abdominal injuries adequately investigated and appropriately managed
- Long bone/pelvic fractures stabilised

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 pCO₂ (also acts as ventilator disconnection alarm)
- Temperature

Whilst every effort is made to keep children warm during preparation for transport some exposure and cooling is inevitable.

Copies of notes and radiological investigations (hard copy, CD or PACS transfer) must accompany the patient

Care of relatives

Prior to departure we normally update the parents and relatives on the condition of their child. Due to limitation of space we may not always be able to allow a parent or relative in the ambulance during transfer. However we will make every effort to make this possible, particularly when a child is being transferred awake. We provide maps and detailed explanations on how to find the PICU. We recommend that parents 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 (shower, get fresh clothes, see other children 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 those parents who go home

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 PICU retrieval 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 estimate
 - 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 tube (ETT)

Neonates and infants

Age	Weight (kg)	Internal Diameter (Size)	Length at Lip (cm)	Length at Nose (cm)
newborn	2	3.0	7	9
newborn	3	3.0	8.5	10.5
newborn	3.5	3.5	9	11
3 month	6.0	3.5	10	12
1 year	10	4.0	11	14

Children aged 1 year and over

Pre pubertal children should be intubated with uncuffed tubes.

Diameter

ETT size can be estimated using the following formula:

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

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

Age	Internal diameter (Size)	Oral tube Length at Lip (cm)	Nasal tube Length at Nose (cm)
18 months	4.0 – 4.5	12	16
24 months	5.0 – 5.5	14	17
2 – 4 years	5.5 – 6.0	15	18
4 – 7 years	6.0 – 6.5	16	19
7 – 10 years	6.5 – 7.0	17	21
10 – 12 years	7.0 – 7.5	20	22 - 25

Table adapted from Hazinski

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

Length

$$\text{ETT length in cm Oral tube} = \frac{\text{Age}}{2} + 12$$

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

Tubes are not usually cut precisely to length but left with 2 - 3cm beyond the lips or nose to allow for later adjustment, for fixation and some flexibility if the child moves its 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 no more than the internal diameter of the tube in mm. e.g.

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

- A tube that is too short may result in an excessive leak and increases the risk of accidental extubation
- Tube postion must be confirmed by X-ray. The ideal position is opposite the body of the 2nd thoracic vertebra. This usually corresponds to the tip of the tube just below the heads of the clavicles.

Method

Awake intubations are **almost never** indicated.

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

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

* 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 in appropriate doses prepared

Potential contraindications to rapid sequence induction

- Anticipated difficult intubation e.g. congenital or acquired airway abnormalities.
- Upper airway obstruction (e.g. epiglottitis).
- Specific contraindication to the use of suxamethonium.

Contra-Indications to Suxamethonium
Recent burns or crush injuries*
Neurological deficit (e.g. spinal injury)*
Renal failure with a raised serum potassium
Severe hepatic failure
Hyperkalaemia
Myasthenia gravis
Myotonia
Muscular dystrophy
History of malignant hyperthermia
History of cholinesterase deficiency

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

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 & atracurium) once oral intubation has been accomplished, and commence infusions before attempting nasal intubation.
- 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 and stomach,
 - end tidal carbon dioxide monitoring – we use capnography or disposable EtCO₂ 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 lie just below the heads of the clavicles.
- **Measure blood gases to verify correct ventilator settings.** A combination of capillary gas and a good SpO₂ 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.

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.

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 (for larger tubes, > 5.5) 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 5.5.

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 SpO₂ and give you some "breathing space".

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 control ventilators than with volume control 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 CO₂ 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.

Humidification

Humidification of gases is important for a number of reasons:

- To minimise heat loss.
- To minimise insensible fluid losses.
- To prevent drying of secretions.

The lack of adequate humidification can increase the frequency of blockage of the tube by dried secretions and therefore the frequency with which the tube needs to be changed.

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 cmH₂O. 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. 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 becoming 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.

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. It can prove useful when establishing a patient on IPPV. You must consider apparatus dead space in small children.

Blood Gases

Although arterial lines are often used, the technical difficulties of inserting them means that many children ventilated for respiratory failure are managed without them.

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 around 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 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 PaCO₂)

If oxygenation is adequate (usually SpO₂>92% at FiO₂ < 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 PaCO₂)

Before adjusting ventilator settings in response to a rise in PaCO₂ 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 migrate 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?

Once these factors have been excluded, you need to consider if there are non-pulmonary problems which mandate a normal PaCO₂ 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 run an elevated PaCO₂, and if so, are the current values significantly higher than normal. Are your ventilator pressures already high, 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)

Typical requirements are as shown in the table:

Term Neonates	
Day 1	60 ml / kg / day
Day 2	90 ml / kg / day
Day3	120 ml / kg / day
Day 4+	150 ml / kg / day

1 to 6 months	120 ml / kg / day
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6 months upwards	Either	Or
(5 - 50 kg)	100 ml / kg / day for the 1st 10 kg	4 ml/kg/hr for 1 st 10 kg
	50 ml / kg / day for the 2nd 10 kg	2 ml/kg/hr for 2 nd 10 kg
	20 ml / kg / day for each additional kg.	1 ml/kg/hr for each additional kg
> 65 kg	2400 ml / day	

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 0.9% normal saline (± 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 ml / kg of Sodium Chloride 0.9% or colloid. Reassess (pulse, blood pressure, capillary refill, urine output) and repeat as necessary.
- In trauma, initial boluses should be 10ml/kg.
- The use of colloid is not recommended in traumatic brain injury.
- Volumes in excess of 100 ml / 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 ml / kg are required, the use of inotropes and ventilatory support and discussion with PICU should also be considered. (See inotropes below.)

2.6. Inotropes

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 ml / kg have been given during a resuscitation.

Notes on the use of inotropes and other cardiovascularly active drugs.

- Ensure adequate preload before commencing inotropes or other agents.
- Give fluid boluses of 20 ml / kg as required.
- If, despite 40 ml / 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 microgram / kg / min) or dopamine (5 -10 microgram/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 low dose (up to 10 microgram/kg/min) dopamine can be safely given via a peripheral cannula. Adrenaline can also be given through a peripheral cannula or an IO needle, but a dilute solution should be used and the site observed carefully for extravasation.

- 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 septic shock (hydrocortisone 2mg/kg IV qds)
- Vasopressin

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.

Caution: Prostaglandin E may cause apnoeas or respiratory arrest especially at higher doses, therefore such children may require intubation and ventilation for transfer.

Prostaglandin E

(There are two preparations available, Prostaglandin E1 (Alprostadil) and Prostaglandin E2 (Dinoprostone) - either can be used and must be specified on the prescription chart)

Infusion: 75 micrograms x body weight (kg) in 50 ml diluent

Suitable diluents: Sodium chloride 0.9%

Glucose 5%

Glucose10%

Dose range : 10 – 200 nanograms / kg / min (0.4 – 8 ml/hr) COMMENT cBNF top dose is 100

Prostaglandin to be made up:

75 microgram / kg of prostaglandin into 50 ml of diluent.

1ml/hr = 25 nanogram /kg/ min

e.g. for a 3 kg baby, 3 x 75 = 225 microgram in 50 ml

2.7. 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 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.

Propofol

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

Propofol can be used in all ages for induction and maintenance of anaesthesia and for anaesthesia for short procedures on PICU.

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.

SECTION 3

CLINICAL GUIDELINES

Note:

Information provided on use of drugs and recommended doses reflect the current practice on the PICU. 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/hr
- Hypotension (late sign)

Treatment

Early, aggressive and appropriate management improves survival.

Therapeutic end-points are:

- Capillary refill time 2 seconds or less
- Normal pulses with no difference in volume between central and peripheral pulses
- Normal mental status
- Urine output > 1ml/kg/hr
- Normal blood pressure for age
- Normal blood glucose
- Normal ionised calcium

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 ml/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 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 microgram/kg/min)
- Obtain central and arterial access
- Continue fluid boluses (up to 200ml/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 bicarbonate if pH remains below 7.15
- Consider steroids (2mg/kg hydrocortisone) 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 ml/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 ml/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

Management after intubation.

- Sedate and paralyse (midazolam ± morphine + muscle relaxant of choice)
- Ventilate at tidal volume (V^t) 5 - 7 ml/kg
- Normal PaCO₂ (4.5 – 5.5 kPa) if possible with normal V^t
- May unmask pulmonary oedema
 - Suction
 - Ventilate with high PEEP (up to 15 cmH₂O)
 - Continue volume resuscitation if necessary

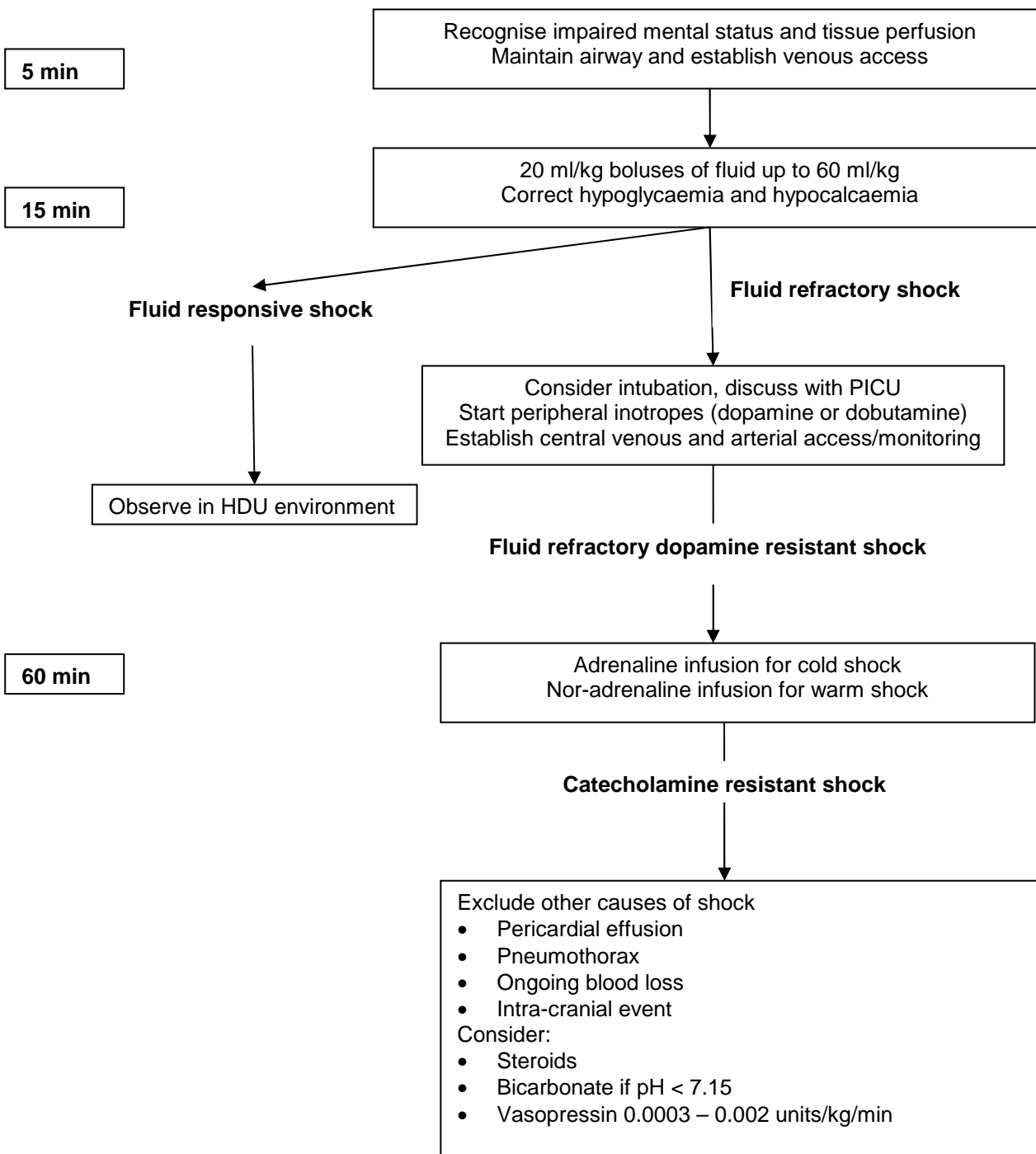
Raised intracranial pressure (ICP).

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 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 over 20 minutes)
- Steroids (dexamethasone 0.4 mg/kg bd for 2 days)
- Intubate and ventilate to PaCO₂ 4 – 4.5 kPa



Adapted from Surviving Sepsis International Consensus Guideline 2007

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. The use of CPAP (in units with trained staff and equipment) may reduce the frequency with which children need referral to PICU. Units that are unable to deliver CPAP are encouraged to discuss those children who meet criteria for CPAP with the PICU.

Indications for referral to PICU include the following:

- Hypoxaemia
- Exhaustion leading to hypercarbia
- Respiratory failure (mixed pattern)
- Apnoeas unresponsive to CPAP
- Septicaemic picture with cardiovascular collapse
- Failure of CPAP
- An inability (staff, equipment or capacity) to deliver CPAP in a baby with indications for CPAP

Nasal Continuous Positive Airway Pressure (NCPAP)

Consider additional respiratory support with NCPAP if two or more of 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
- rising PaCO₂ (> 3 kPa from baseline)
- respiratory acidosis (pH 7.2 – 7.25, if pH < 7.20 consider ventilation)

Contraindications to NCPAP

- 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 make NCPAP, or Nasal Mask (NM)-CPAP ineffective or potentially dangerous (e.g., choanal atresia, cleft palate, tracheoesophageal fistula).
- Pneumothorax.
- Inadequate staffing (numbers **and** expertise) or equipment to deliver and monitor safely (see below).

Management

- 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 4 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 max 8 cm.
 - If SpO₂ remains < 92%.
 - (Re) Xray (to exclude barotrauma).
 - Check efficacy of CPAP (see below).
 - Consider ventilation.
- Treat any presumed secondary bacterial infection
 - Take blood culture and throat swab/NPA.
 - Start antibiotics if indicated - iv cefuroxime or follow local policy.
- Pass nasogastric or oro-gastric tube and leave on free drainage. Aspirate tube 4 hourly.

Monitoring

- Continuous HR, RR and SpO₂ monitoring.
- Transcutaneous CO₂ monitoring if available.
- Half hourly recording of observations for the first 4 hours.
- Hourly recording after 4hours if patient is improving.
- Repeat blood gas measurement within 1 hour.
- Fluid balance.
- Daily U&E if on IV fluids .

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 fluid bolus(es)).
- 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 FiO_2 (eg >0.8) will cause alveolar collapse due to loss of nitrogen splinting.

Assessment

Success 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 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 $FiO_2 0.8$ and CPAP 8cmH₂O.

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 Anesthetist / Intensivist).
- Review need for IPPV.

Fluid management/feeding

- Stop feeds initially .
- Give IV fluids: restrict intake to 80% of estimated maintenance requirements using sodium chloride 0.45%/glucose 5% with 10 mmol potassium chloride per 500 mL.
- If stable for 24 - 48 hrs and still requiring CPAP consider naso-gastric feeds.
- Observe infant for signs of stomach distension and/or non-absorption of feeds.

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).

Discontinuation

- Need for IPPV.
- Intractable gastric distention and diaphragmatic splinting.
- If no progress at 72 hours:
 - Discuss with PICU.
 - Review diagnosis/co-morbidity.
 - Consider IPPV.
- Therapy is weaned if the infants condition improves and there are no clinically significant apnoea for 12 hrs
 - Reduce FiO₂ to keep SpO₂ 92-95%.
 - Once FiO₂ less than 0.4 (40%) reduce CPAP pressure in increments to 5cmH₂O.
 - Trial off CPAP.

Equipment 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 or transcutaneous monitor.
- Continuous transcutaneous CO₂ monitoring is optional.
- 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.

Personnel:

CPAP should only be used in units where:

- Nurse staffing levels are adequate to ensure a minimum of 0.5:1 nurse:patient ratio 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.

Intermittent positive pressure ventilation (IPPV)

Airway / Breathing

- Intubate and ventilate.
- Moderate hypercarbia (PaCO₂ < 8 kPa, pH > 7.25) 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 is frequently 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 20 mmol potassium chloride per litre (see page 25).
- Adequate fluid input should maintain urine output of 1 – 2 ml / 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 / morphine and muscle relaxant (e.g. atracurium) are appropriate in the first instance.
- Once the child's condition is stable the need for continuing sedation and / or muscle relaxation can be reassessed.

3.3 Head injuries

Indications for CT scan and for referral to a neurosurgeon are detailed in NICE guidelines (www.nice.org/cg056).

Referrals are to a neurosurgeon in the first instance.

Referring units need to maintain the capacity to provide emergency transfers for children with time-critical neurosurgical emergencies.

Note: Open door policy

Children who require emergency neurosurgical intervention will not be refused regardless of the PICU bed state. They will be accepted and then arrangements made for their continuing care after definitive treatment.

It is not appropriate to transfer **all** children who fulfil the criteria for admission (e.g. children with catastrophic head injuries and a terminal prognosis). In such situations, the decision whether or not to transfer a patient to the neurosurgical centre is made following discussion between the referring centre, the neurosurgeons and the consultant in Paediatric Intensive Care.

Management

The objective of the management of severe head injuries is to prevent secondary brain injury by:

- Ensuring adequate cerebral perfusion
- Ensuring adequate cerebral oxygen delivery
- Providing timely surgical intervention where appropriate

Resuscitation should follow normal APLS protocols

Airway / Breathing

- All head injured children requiring admission to PICU should be intubated and ventilated for transfer
- Head should be kept central in the neutral position
- C-Spine measures – hard collar, sand bag and tape should be continued once the child is paralysed and sedated. Avoid neck constriction - check collar size.
- Nasal intubation and nasogastric tube are contraindicated until basal skull fracture has been excluded. (Intubate orally and pass oro-gastric tube)
- Intubation should be effected with a conventional rapid sequence induction.
- Once intubated, continue muscle relaxants and sedation (see table) to prevent rises in ICP

Muscle relaxant	Atracurium Vecuronium	1 – 3 mg / kg / hr 100 micrograms /kg /hr
Sedation under 8 years over 8 years	Midazolam Midazolam	4 – 6 micrograms / kg / min 2 - 4 micrograms / kg / min
Analgesia	Fentanyl or Morphine	4 – 6 micrograms / kg / hr 20-40 micrograms / kg/ hr

(Propofol is no longer recommended for sedation of children receiving intensive care although it can be useful for anaesthesia in children undergoing CT scanning.)

- Xray the chest to confirm the ETT position and to exclude pneumo/haemothorax
- Ventilate to a pCO₂ of 4.5 – 5.0 kPa
- Maintain SPO₂ > 95% and PaO₂ > 12 kPa
- Check blood gases before transporting and correlate to EtCO₂

Circulation

- Give fluid as needed to maintain arterial pressure above age specific values (see below)

Systolic Blood Pressure by age	
Age (in years)	Systolic blood pressure (mm HG)
< 1	70 – 90
2 – 5	80 – 100
5 – 12	90 – 110
> 12	100 - 120

- In trauma, initial boluses should be 10ml/kg.
- The use of colloid is not recommended in traumatic brain injury.
- Commence noradrenaline if necessary to support blood pressure
- Control ongoing blood loss, especially scalp lacerations, fractures, intra-abdominal trauma.
- Adequate fluid volume resuscitation should result in urine output of > 1 ml/ kg / hr
- Monitor CVP if central access obtained. Keep CVP >10
- It is more important to stabilise and expedite transfer of the child with an expanding intracranial lesion than to lose time or further compromise the child with unsuccessful attempts at central cannulation
- Check haemoglobin. Keep Hb > 10 g / dl

Expanding intracranial haematoma

- 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% 2.5 ml/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.)
- Monitor pupillary responses.
- Site a urinary catheter.
- 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 PaCO₂ 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.
- Temperature. Do not allow temperature to rise above 37°C. Allow passive rewarming of patients with a core temp 32-37°C.

3.4. Cervical spine injury

The incidence of cervical spine injury in children is not trivial and management of potential injury in children is often sub-optimal.

Any child with an injury in which there is a risk of cervical spine injury should be managed with 3 point immobilisation (collar, sandbags and tapes) until the cervical spine can be “cleared”.

Adequate clearance of a cervical spine injury must include the following features:

- Normal radiology: An adequate CT scan (C0 – T3 bone detail spine) with reconstruction reported by an experienced radiologist.
- An absence of neurological deficit.
- An absence of neck pain or tenderness in a co-operative patient without a distracting injury.