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Paediatric Innovation, Education and Research Network

Wessex children's major trauma guidelines

Trauma Unit version

Updated July 2017

Wessex PCCN
WESSEX PAEDIATRIC CRITICAL CARE NETWORK

Wessex Trauma Network

SOUTHAMPTON Children's Hospital

Wessex children's major trauma guidelines

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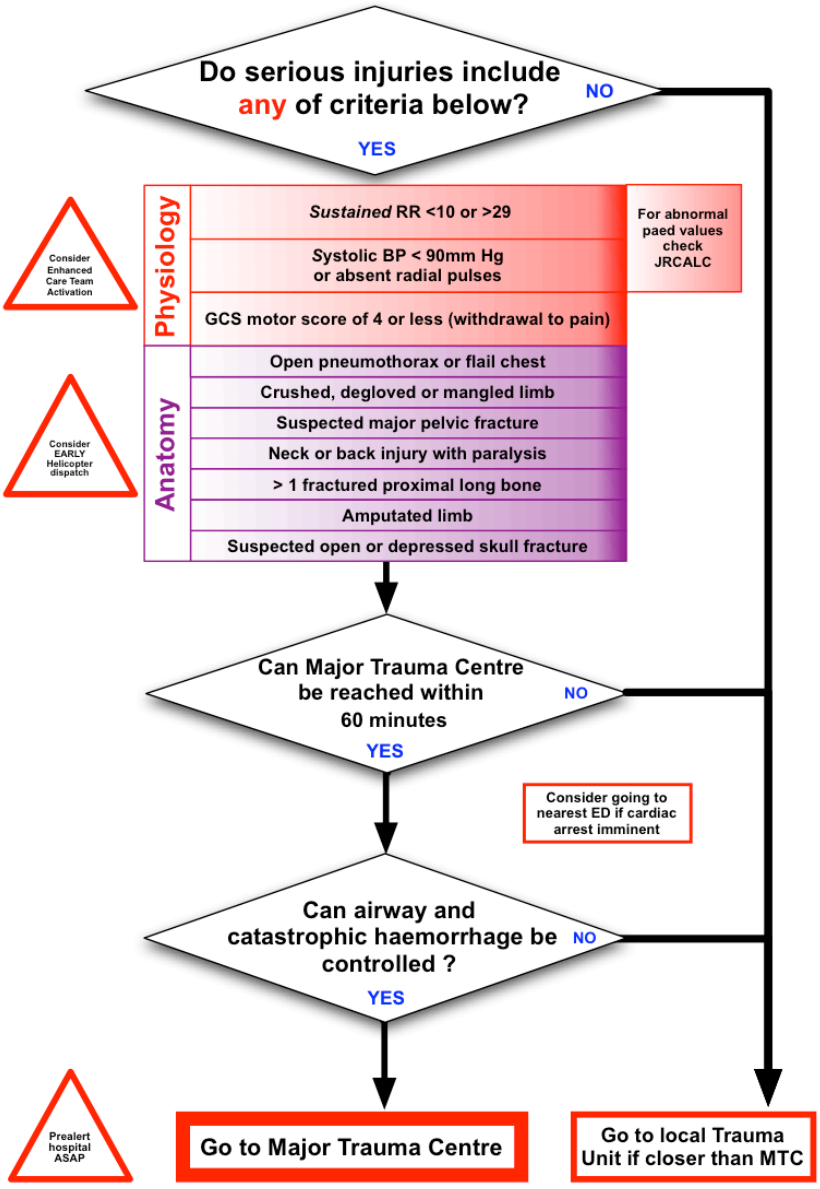
CHILDREN'S MAJOR TRAUMA TEAM

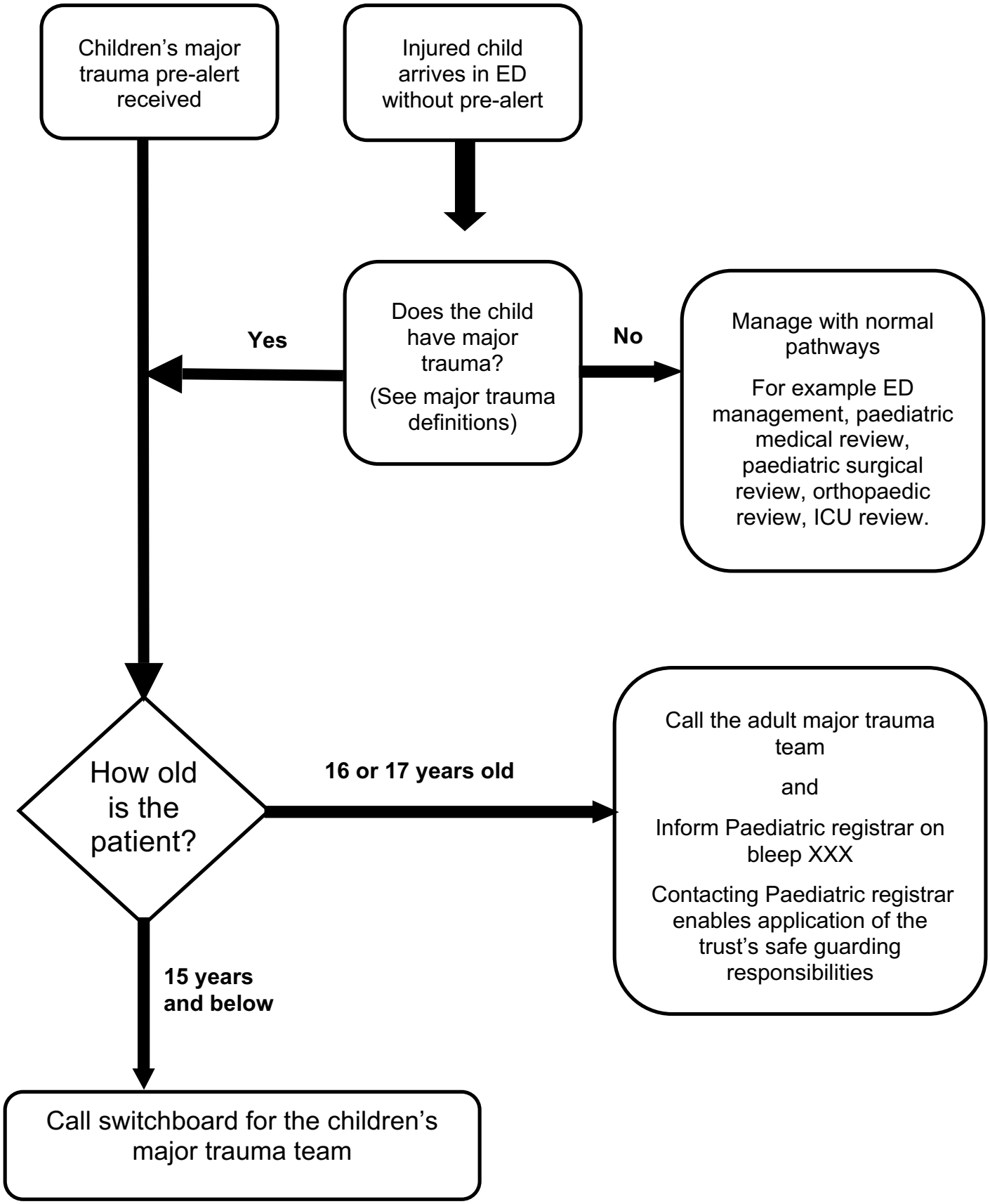
Pre-hospital major trauma bypass tool

Children should be brought directly to the John Radcliffe Hospital or Southampton Children's Hospital if they trigger the pre-hospital major trauma bypass tool or if a pre-hospital critical care team chooses to bypass. A pre-alert will be provided by the ambulance service to the emergency department. The children's major trauma team is then activated (see children's major trauma team activation). The pre-hospital bypass time used by the ambulance service was extended from 45 minutes to 60 minutes in 2016.



Pre-hospital major trauma bypass tool used by South West and South Central ambulance services. **JRCALC** stands for the guidelines produced by the Joint Royal Colleges Ambulance Liaison Committee.

Children's Major Trauma Team Activation



Children's major trauma definitions

A	Airway compromise	Airway injury, facial injury, penetrating neck injury, intubated
B	Breathing compromise	Respiratory failure, pulmonary contusions, open pneumothorax, multiple rib fractures, flail chest, haemothorax
C	Cardiovascular compromise	Shock, haemothorax, intra-abdominal or retro-peritoneal bleeding, pelvic disruption
D	Neurological compromise	GCS motor score of 4 or less, traumatic seizures, pupil abnormalities, intracranial haemorrhage, brain injury, open or depressed skull fracture
E	Environmental injury	Core body temperature below 35 degrees Celsius, frostbite, drowning.
	Peripheral injuries	Crushed, degloved or mangled limb, 2 or more fractured proximal limb bones, Amputated limb, nerve or vascular injuries
	Spinal injuries	Spinal fractures, spinal cord injury or nerve root injury
	Burns	Greater than 20% body surface area, inhalational burns, electrical burns, chemical burns

Children's Major Trauma Team constituents and responsibilities

Children's major trauma team activated by a call to switchboard

Team immediately assemble in the resuscitation area of the Emergency Department

Report to the scribe and give name, specialty and seniority

Members of the children's major trauma team

Role	Responsibilities
ED consultant	Team Leader
ED registrar	Primary survey
ED senior nurse	Supervision
ED nurse 1	Nursing team leader (monitoring)
ED nurse 2	As directed by nurse 1
ED scribe	Assisting nurse 1 and 2. Documentation
Senior anaesthetist	Airway and anaesthetic management of the child. Escorting of ventilated child to CT scanner/theatre/ICU.
Airway assistant / ODP	Assisting the anaesthetist
Paediatric nursing bleep holder or outreach nurse	Paediatric nursing input. Liaison with families. Contact family early.
Paediatric registrar	Vascular access, history from family, safe guarding
Adult surgical registrar	Assessment and escalation of any surgical interventions
Intensive care consultant	Critical care and decision support for major trauma patients. Plan for onward care and destination.

Major trauma team etiquette

The trauma team has an important role to play in effective horizontal resuscitation of the severely injured child. Following these guidelines will help in developing a coordinated response and enhance the 'human factors' elements of team work.

1) Respond to paediatric trauma team calls immediately

2) Arrive promptly in the emergency department resuscitation rooms to receive the Trauma Team brief – this avoids multiple handovers.

3) First introduce yourself by name, specialty and level of seniority to the Scribe to ensure these are documented. Wear specialty sticker + write your name underneath.

4) The team will use first names for communication between team members unless otherwise advised by the individuals.

5) Familiarise yourself with who is the emergency department Trauma Team Leader (TTL).

6) Mission rehearsal - Engage in preparation for the patient's arrival, under the guidance of the Trauma Team Leader (TTL) and using the pre-arrival checklist *(see page 15)*.

7) On arrival of the patient, listen to the pre-hospital team's 'Hands Off Handover'. Everyone should stand and listen; activity causes distraction. The handover should take no longer than 45 seconds.

8) If there is cardiopulmonary resuscitation in progress, catastrophic haemorrhage or a compromised airway the patient will be moved onto the emergency department trolley and handover will happen after transfer and during simultaneous team activity.

9) If you require equipment or investigations please go through the Trauma Team Leader (TTL).

10) Try to keep noise to a minimum

11) If leaving the resuscitation room, please 'check out' with the scribe.

12) Please stay for the hot debrief

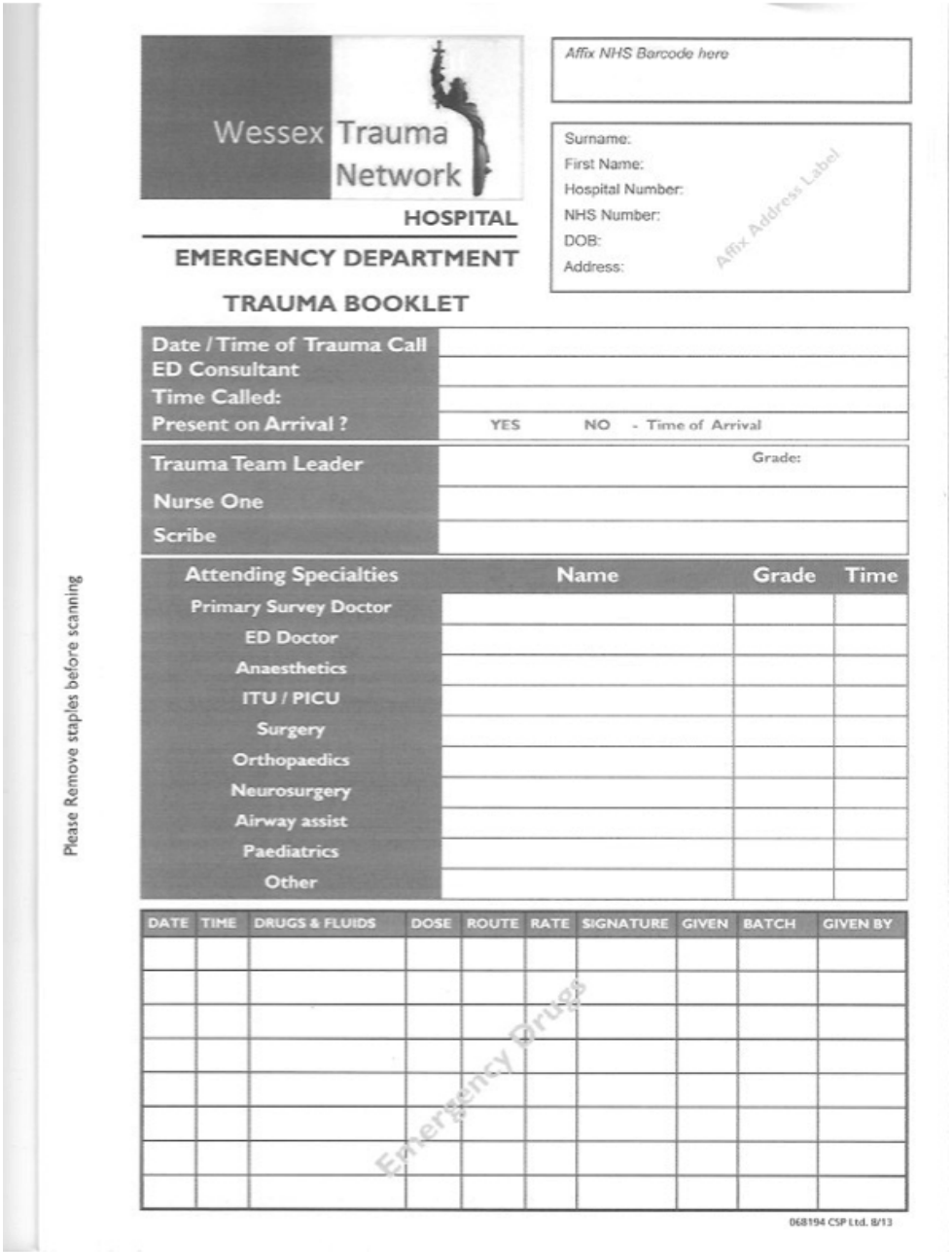
Children's major trauma team extended contact list

In addition to the bleep system below, for all services, there is a 24/7 on call consultant who can be accessed through switchboard.

	0800h to 1700h	1700h to 0800h
Anaesthetic consultant	Bleep	Bleep
CT scanner	Extension	Extension
ENT surgery	Ring	Ring
General surgery	Bleep	Ring
Intensive care	Bleep	Bleep
Ophthalmology	Ring	Ring
Orthopaedic surgery	Bleep	Ring
Paediatrics	Bleep	Bleep
Plastic surgery	Bleep	Ring
Radiologist	Extension	Ring

Major trauma documentation

All paediatric major trauma patients have their clinical course documented within the Wessex Trauma Network trauma booklet. The booklet enables data collection about children's trauma and ensures that important parts of the trauma pathway are recorded. We use standardised pre-arrival and pre-departure checklists in the emergency department to ensure that the team is well prepared for the arrival and transfer of patients.
The front page of the booklet is shown below:



Wessex Trauma Network

HOSPITAL

EMERGENCY DEPARTMENT

TRAUMA BOOKLET

Affix NHS Barcode here

Surname:
First Name:
Hospital Number:
NHS Number:
DOB:
Address:
Affix Address Label

Date / Time of Trauma Call	
ED Consultant	
Time Called:	
Present on Arrival ?	YES NO - Time of Arrival
Trauma Team Leader	Grade:
Nurse One	
Scribe	

Attending Specialties	Name	Grade	Time
Primary Survey Doctor			
ED Doctor			
Anaesthetics			
ITU / PICU			
Surgery			
Orthopaedics			
Neurosurgery			
Airway assist			
Paediatrics			
Other			

DATE	TIME	DRUGS & FLUIDS	DOSE	ROUTE	RATE	SIGNATURE	GIVEN	BATCH	GIVEN BY

Emergency Drugs

068194 CSP Ltd. 8/13

Please Remove staples before scanning

Paediatric Trauma Pre Arrival Checklist v1.3

ALL PATIENTS

Prior to team arrival: (Confirm **paeds** trauma team has been activated)

- ☐ ED Consultant on route or present?
- ☐ Write details of case on white board in bay
- ☐ Ensure SORT calculations done & printed.
- ☐ Pre alert paeds radiologist (in hrs x OOH's via switch)
- ☐ Ensure radiographer present – CXR & lateral C-Spine likely.
- ☐ Yellow scoop needed?
- ☐ Bair hugger & sheet ready?
- ☐ Open fracture? Get antibiotics ready. Confirm allergies prior to drawing.
- ☐ Significant Neuro trauma?

CODE RED ONLY

Prior to team arrival:

- ☐ Identify code red nurse (do you need a code red team?)
- ☐ Confirm hospital number (T number: ED or HEMS)
- ☐ Pre alert transfusion. Inform lab patients age/weight
  Reminder: Octoplas (FFP'96) takes time to defrost. Use FFP if peri-arrest.
- ☐ Confirm with code red nurse if priming belmont. (only if solid info)
- ☐ Do you need someone in a gown ready to insert a central trauma line?
- ☐ Do you need a consultant general surgeon here right now? (*usually = yes)*
- ☐ Ultrasound set up, operator identified
- ☐ Consider pre alert to Interventional Radiology

Reminders:
- •TXA 15mg/kg
- •Pack 1 = PRBC's 20ml/kg + Octoplas 20ml/kg
- •Check a blood gas every 15-20mins
- •Order Pack 2 if ongoing bleeding

Aims:
- •Blood/FFP 5mls/kg boluses if obvious bleeding. N Saline 5mls/kg if not obvious. (Always warm fluid)
- •Calcium >1 (0.1ml/kg 10% CaCl)
- •Plts >75 (or >100 in neuro trauma)
- •Fibrinogen >2 (Cryo 10ml/kg)

TEAM BRIEFING

Team briefing:

- ☐ Confirm patient ETA & Clinical details
- ☐ Introductions and assign roles
- ☐ Team leader/Airway lead/Nurse 1 (as minimum) – wear lead.
- ☐ Who is doing access – are they the best person?
- ☐ Family liaison & play specialist?
- ☐ Mission rehearsal: Plan A is….. Plan B will be……
- ☐ Is direct to theatre likely to be needed – who will coordinate this?
- ☐ Crowd control: Anyone without a primary role, outside bay.

Reminders:
- •CT head as per NICE guidelines
- •CXR & Lateral Neck on arrival*
- •PXR if indicated
- •USS Abdomen – radiologist (FAST not validated)
- •No collars; blocks & tape is fine.

Once discussed case with paeds radiologist inform CT radiology SpR plan.
*Trend away from CT C-spine. Consider MRI.

ED Transfer Checklist

A Clinician should perform this checklist prior to leaving the ED with **any adult critical transfer and ALL PAEDIATRIC TRANSFERS**. Go through the checklist with the team who will be transferring the patient. Brief together prior to leaving the ED. Cross through points not required.

Date: Time:

ALL PATIENTS

Patient:

- ☐ Analgesia adequate
- ☐ Airway secure
- ☐ IV Cannula secure
- ☐ Temperature Management
- ☐ Blood sugar checked
- ☐ Oxygen required YES / NO
- ☐ More fluid required YES / NO
- ☐ Antibiotics YES / NO

ALL PATIENTS

Monitoring & Equipment:

Yes	n/a		Yes	n/a	
☐	☐	SpO2	☐	☐	ID Bracelet (x2)
☐	☐	EtCO2	☐	☐	Suction checked
☐	☐	ECG	☐	☐	Oxygen checked
☐	☐	BP	☐	☐	Transfer Bag
☐	☐	CT/XR Request	☐	☐	Transfer drugs & Fluids
☐	☐	Notes Printed +/- completed	☐	☐	Defib required & Attached?
			☐	☐	CD Book signed

TRAUMA ONLY

Trauma Transfers:

- ☐ Head up
- ☐ Tetanus required
- ☐ Tranexamic Acid
- ☐ Group & Save
- ☐ Cross match……(units)
- ☐ Location of blood?

CHILDREN ONLY

Paediatric Transfers:

- ☐ ED arrival PEWS score……
- ☐ Pre transfer PEWS score……
- ☐ Confirm no significant change

Temp:	HR:
RR:	O2 Sats:
Cap Refill:	GCS:

ALL PATIENTS

Planned destination is:
(and confirmed ready)

Plan for deterioration

- ☐ Most likely complication is…… and has been planned for
- ☐ Roles & Equipment brief
- ☐ If problems develop on route divert to? (ED Resus or Destination)

For immediate help on route call

GO, GO, GO

Signed (Transferring clinician)……..

CATASTROPHIC HAEMORRHAGE

Treatment of external haemorrhage

Limb injuries with haemorrhage
Bleeding limb injuries are treated with elevation of the limb and direct manual pressure on the bleeding point.
Chitin impregnated gauze can be used to apply direct pressure onto the wound.
On-going pressure can be applied using elasticated compression bandages. These are meant to be applied firmly but not to act as a tourniquet.
Uncontrolled haemorrhage of limbs can be stopped using a specifically designed tourniquet – see tourniquet guidance.

Neck, armpit or groin injuries with haemorrhage
Injuries to the neck, armpit or groin such as stab wounds or traumatic amputations can bleed significantly.

Initial treatment is direct manual pressure with haemostatic gauze.
Tourniquets cannot be used for these wounds – as there is no proximal limb to compress.

Further surgical management includes clipping of bleeding exposed vessels and proximal control of major vessels. The vascular surgical team should be requested to support care in these circumstances.

Tourniquet use in children with major trauma in the emergency department

Introduction

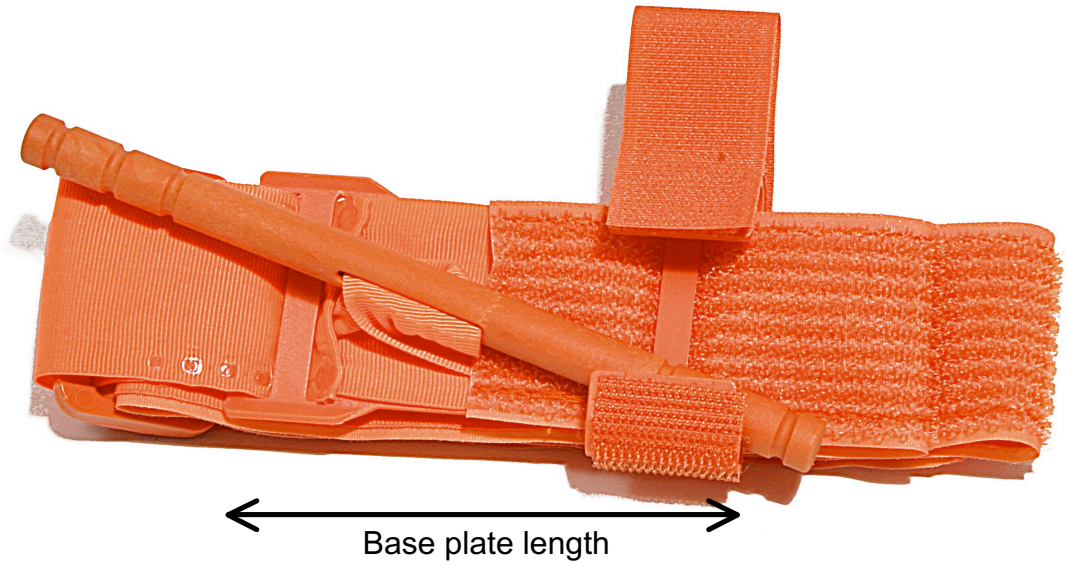
Haemorrhage from limbs which is uncontrolled by direct pressure, elevation and haemostatic bandages can be stopped by applying circumferential pressure to the limb above arterial pressure. This can be achieved with commercially available tourniquets.

Indications for tourniquet use

Uncontrolled limb haemorrhage.

Equipment

'CAT' tourniquet (combat application tourniquet)
Plain bandage



Application of tourniquet

1) The tourniquet has a plastic central base plate. This provides a physical limitation to how small the tourniquet can be tightened.
2) If the bleeding limb is wider than the base plate then the CAT can be directly applied to the limb.
3) If the limb is narrower than the base plate, then increase the limbs size by winding a plain bandage circumferentially around the limb. The CAT can then be applied around the bandage.
4) The CAT is placed around the bleeding limb, as close to the bleeding point as possible.
5) The Velcro strap is tightened and adhered to itself.
6) The windlass is tightened until bleeding is stopped.
7) The windlass is tucked under the windlass clip and held in place by the windlass strap.
8) The tourniquet is only removed within theatre by the surgical team.

Emergency department pelvic splintage in children

Introduction

The splint function is to decrease the volume of the disrupted pelvis and promote haemostasis by splinting fractured bone.
Repeatedly stressing and moving the child dislodges blood clots and promotes bleeding.

Indications for pelvic splintage

Obvious or potential pelvic disruption – see below for clinical evaluation of the pelvis.

Clinical evaluation of the pelvis

Injured children complaining of pain in the pelvis, lower back or hips should be considered as having an unstable pelvic injury. Vertical shear and open book fractures can often be identified by looking for pelvic asymmetry. Do not stress the pelvis to assess it.

Application of the pelvic splint

In children with suspected pelvic injury, moving and rolling the child should be kept to a minimum. Ideally, the splint should be applied to skin, not over clothing.
The splint is placed at the level of the greater trochanter. Positioning is important as a badly positioned belt may serve to open the pelvis. The endpoint of the splint is to bring the pelvic bones into a near anatomical position. The straps should therefore not be tightened "as much as possible" as this may serve to open a posterior disruption, but rather tightened to achieve anatomical pelvic alignment.

Removal of pelvic splint

The splint should only be removed when other means of stabilisation / splintage can be initiated or after full radiological imaging excludes instability. (Imaging should be performed through the splint).

AIRWAY and ANAESTHESIA

Suggested emergency anaesthetic drug packs

UHS Emergency anaesthetic drug packs

2 packs are needed, pack 1 and pack 2
Drug pack 1 (yellow) – bottom shelf of fridge in resuscitation area

Drug pack 2 (blue/orange) – inside the controlled drug cupboard

Place pack 1 and pack 2 on top of the children's airway and breathing trolley.

Position the airway trolley at the head end of the bed on the patient's right side.

Do not draw up any drugs – this is the anaesthetic team's responsibility.

We have found that the use of standardised drug packs has reduced the time to RSI, allows consistent practice amongst clinicians and reduces confusion in a time pressured stressful event.

Suggested drug choice for anaesthesia in children with major trauma within the emergency department

Child with major traumatic injury of any type needing emergency anaesthesia within the emergency department

INDUCTION AGENT
Ketamine 0.5mg – 2mg/kg

Ketamine does **not** increase intracranial pressure.[1, 2, 3,4] The lower dose range is used for induction in cardiovascular instability

MUSCLE RELAXANT
Suxamethonium 1.5mg/kg
or
Rocuronium 1mg/kg

Avoid suxamethonium in children with:
Chronic neuromuscular conditions
Renal failure
Burns more than 12 hours old
High spinal cord injuries more than 12 hours old

CONTINUED SEDATION
Morphine infusion 20-80mcg/kg/hour

and

Midazolam infusion 20-80mcg/kg/hour

or

Propofol infusion 2-5mg/kg/hour

Propofol is used for children expected to be woken from anaesthesia within 6 hours.

CONTINUED MUSCLE RELAXATION
Rocuronium boluses 1mg/kg

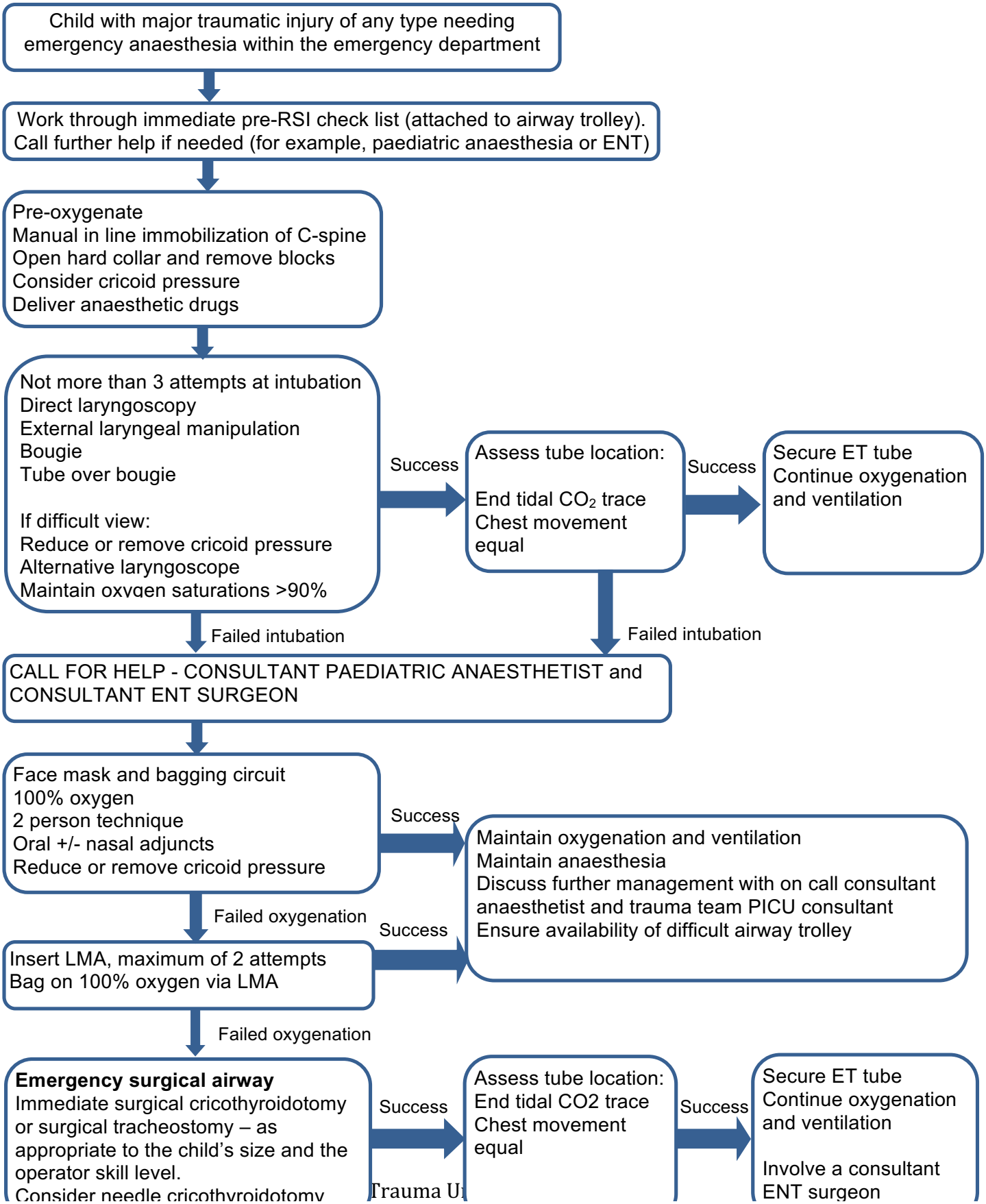
References
1) Roberts DJ, et al Crit Care Med. 2011 Dec;39(12):2743-51.
2) Bar-Joseph G, et al. J Neurosurg Pediatr. 2009 Jul;4(1):40-6.
3) Filanovsky Y, CJEM. 2010 Mar;12(2):154-7.
4) Hirota K, Lambert DG. Br J Anaesth. 2011 Aug;107(2):123-6.

Paediatric IMMEDIATE RSI Checklist

Indication - confirm immediate RSI required and trauma team leader informed

Oxygen + Ventilation; BVM / T-piece or C-circuit attached to high flow Oxygen		Check
Laryngoscope; size 'x' blade + type		Check
ETT size 'x', plus size above + below		Check
Bougie or stylet		Check
LMA or iGEL size 'x'		Check
Difficult airway kit + failed intubation plan		Check
Suction + orogastic tube available		Check
IV in-situ and flushed		Check
Drugs	Ketamine / Rocuronium Doses	Check
	Emergency drugs + fluid	Check
End Tidal Carbon dioxide monitoring Sidestream $ETCO_2$ connected + working		Check
Blood pressure, ECG and oxygen saturations		Check
GCS/ Pupils/ limb movement – Hypertonic saline required?		Check
Tension pneumothoraces Immediate thoracostomies required after RSI?		Check
Manual in line spinal immobilisation		Check
External laryngeal manipulation		Check

Emergency anaesthesia flow chart for children with major trauma in the emergency department



Surgical cricothyroidotomy for children with major trauma in the emergency department

Indication

A surgical cricothyroidotomy allows a definitive airway to be obtained in a 'can't oxygenate and can't intubate situation'.
This procedure may be technically more difficult in children under the age of 5 in whom the cricothyroid membrane may not be easily palpable. In patients whom the cricothyroid membrane is not easily palpable, a surgical tracheostomy should be considered in preference to a surgical cricothyroidotomy and is recommended for all children under 1 year of age. Between the ages of 1-5 years either an emergency tracheostomy or a cricothyroidotomy may be performed.

Equipment

Kept in the children's airway and breathing trolley.

a) Scalpel with number 10 blade
b) Forceps or tracheal dilators
c) Bougie
d) Cuffed endotracheal tube 0.5mm smaller than age appropriate
e) Tube tie

Procedure of surgical cricothyroidotomy

1) Locate the cricothyroid membrane, beneath the thyroid cartilage and above the cricoid cartilage.

2) A scalpel blade is carefully inserted horizontally into the cricoid membrane using a "stab/rocking" technique.

3) Leaving the blade in position the tips of small forceps or a tracheal dilator are pushed into the airway incision on either side of the blade and opened. Dilate the membrane in a vertical manner.

4) The scalpel blade is removed and a lubricated intubating bougie is placed into the hole held open by the forceps or dilators.

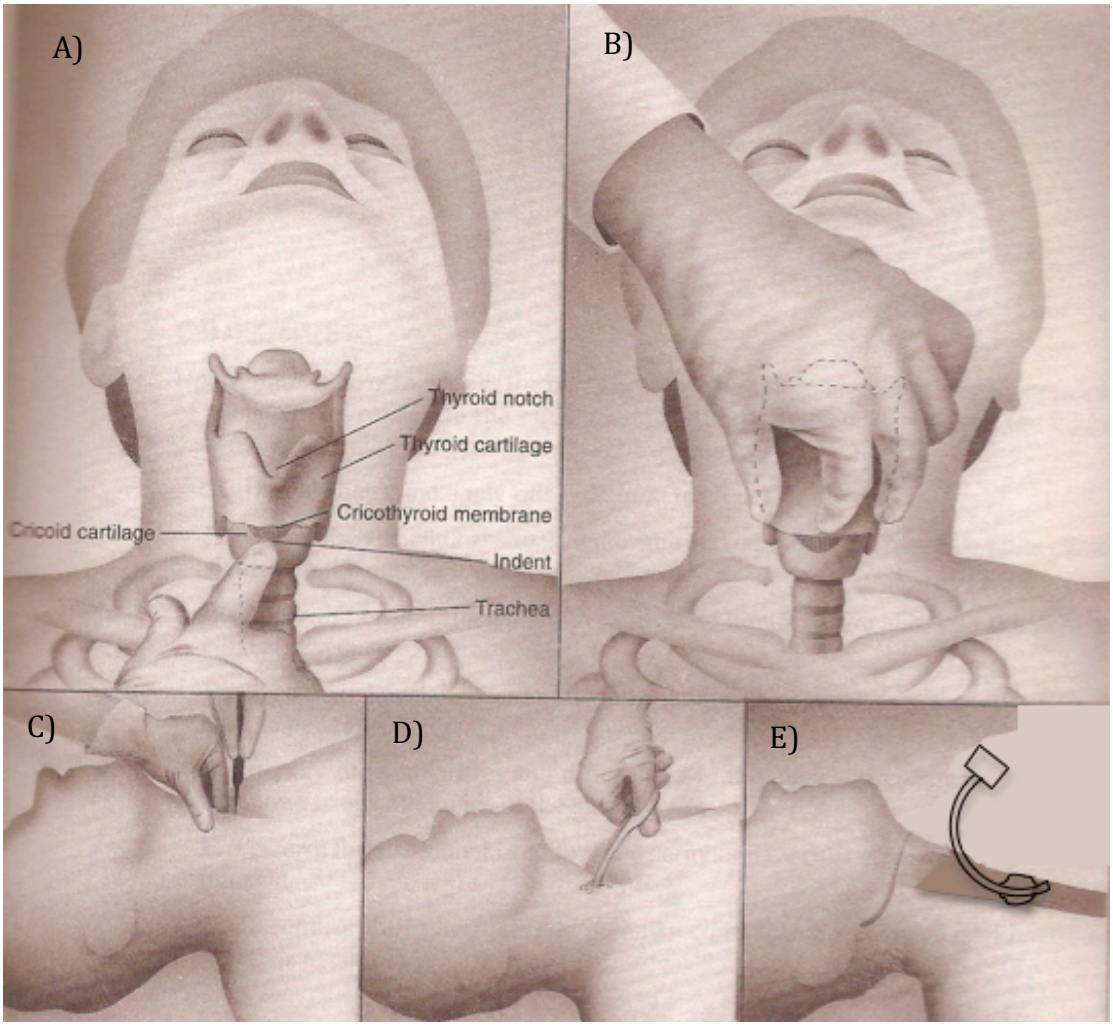
5) A lubricated cuffed normal endotracheal tube is inserted over the bougie. Be aware that the tube insertion point is just below the cords, therefore advance the tube only as far as you would though the cords in a normal intubation (this prevents right main stem bronchus intubation).

6) The endotracheal tube cuff is inflated and tube position confirmed with end tidal carbon dioxide monitoring, chest observation and auscultation.

7) The tube is then fixed in position with a tie, Elastoplast or held manually.

Immediate complications of surgical cricothyroidotomy

Blood aspiration
Creation of a false passage
Haemorrhage
Haematoma
Oesophageal laceration
Mediastinal emphysema



Surgical cricothyroidotomy.
A) Locate cricothyroid membrane. B) Stabilise thyroid cartilage, C) Blade horizontally, D) forceps, dilate and place bougie, E) endotracheal tube over bougie

Surgical tracheostomy for children with major trauma in the emergency department

Indication

A surgical tracheostomy allows a definitive airway to be obtained in a 'can't oxygenate and can't intubate situation'. This procedure is ideally performed by an ENT surgeon.
When an ENT surgeon is not immediately available and in the circumstance of 'can't oxygenate, can't intubate' a surgical airway will need to be performed by a clinician without ENT training.
If the child's cricothyroid membrane is palpable, then the technique of surgical cricothyroidotomy is used (see previous section).
If the child's cricothyroid membrane cannot be felt, the technique of surgical tracheostomy described in this guideline is used.
The procedure of needle cricothyroidotomy has been demonstrated to have a high failure rate in adults, despite the cricothyroid membrane being easily palpable in these patients. A surgical approach to the 'can't oxygenate, can't intubate' situation is advised.

Equipment

Kept in the children's airway and breathing trolley.

a) Scalpel with number 10 blade
b) Forceps or tracheal dilators
c) Bougie
d) Cuffed endotracheal tube 0.5mm smaller than age appropriate
e) Tube tie

Procedure of surgical tracheostomy

1) Extend the child's neck by placing a towel under their shoulder blades. C-spine control is not a consideration in the 'can't oxygenate, can't intubate' situation.

2) Palpate the trachea (the laryngeal cartilages are difficult to palpate in smaller children).

3) Stabilise the trachea with your left thumb and index finger on either side of the neck, this helps to protect the lateral vascular structures from injury.

4) Make a low, vertical, midline incision in the skin, above the suprasternal notch, maintaining pressure and stabilizing the trachea with your left thumb and index finger. Pressure and remaining in the midline will minimize bleeding and damage to lateral vascular structures.

5) Make a vertical incision through the tracheal rings, being careful not to damage the cricoid cartilage. Leaving the blade in position the tips of small forceps or a tracheal dilator are pushed into the airway incision on either side of the blade and opened. Dilate the membrane in a vertical manner.

6) The scalpel blade is removed and a lubricated intubating bougie is placed into the hole held open by the forceps or dilators.

7) A lubricated cuffed normal endotracheal tube is inserted over the bougie. Be aware that the tube insertion point is just below the cords, therefore advance the tube only as far as you would though the cords in a normal intubation (this prevents right main stem bronchus intubation).

8) The endotracheal tube cuff is inflated and tube position confirmed with end tidal carbon dioxide monitoring, chest observation and auscultation.

9) The tube is then fixed in position with a tie or elastoplast.

Immediate complications of surgical tracheostomy

Blood aspiration
Creation of a false passage
Haemorrhage
Haematoma
Oesophageal laceration
Mediastinal emphysema
Thyroid injury

Needle cricothyroidotomy for children with major trauma in the emergency department

Indication

Insertion of a wide bore, non-kinking cannula through the cricothyroid membrane and using this is to deliver oxygen can be lifesaving for children in whom you 'cannot oxygenate and cannot intubate'.

It may provide oxygenation whilst a more definitive airway is organised.

Reported failure rates for this procedure are high. Complications of this procedure can reduce the chance of a surgical airway being placed.

The current recommendation in Wessex is to use an emergency surgical airway in preference to a needle cricothyroidotomy.

Equipment

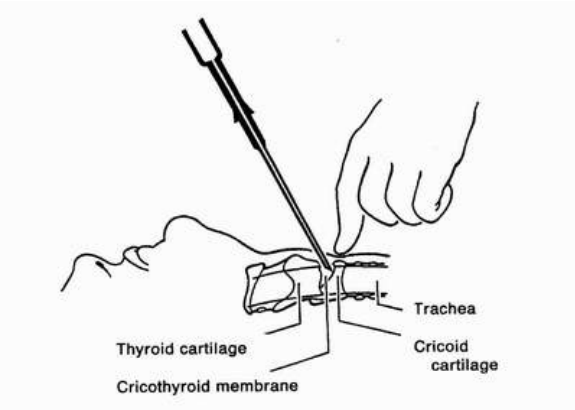
Kept in the bottom draw of the children's airway and breathing trolley.

a) Stiff cannula (14G in adults, 18G in children, 20G in neonates)
b) 10ml syringe
c) Oxygenation system – either Manujet or 3 way tap and oxygen tubing.

Procedure of needle cricothyroidotomy

1) Attach a 10ml syringe to the rear of the cannula and needle.

2) Insert the needle and cannula at an angle of 45 degrees towards the feet through the cricothyroid membrane into the trachea in the midline, as shown in the diagram below.



3) Confirm cannula and needle are inside the trachea by withdrawing air into the syringe

4) Advance the cannula into the trachea and remove the needle.

5) Check the cannula remains in the trachea by aspirating air with the syringe.

6) Hold the cannula securely in place and connect the oxygenation system up to the cannula and oxygen source.

7) Set the oxygen flow rate in l/min to equal the child's age. Occlude the side port for 1 second and release for 4 seconds. The oxygen flow rate should be increased in increments of 1 l/min until one second of oxygen flow creates movement of the chest.
If using a Manujet, then the pressure settings on the Manujet must begin at the lowest and then turned up until the chest is seen to rise.

10) Ensure the chest is falling during the 4 second pause period. 4 seconds pause allows exhalation of gas through the upper airway (exhalation does not occur through the cannula)

11) Arrange more definitive airway management with the on call consultant ENT surgeon.

Immediate potential complications of needle cricothyroidotomy

Subcutaneous and/or mediastinal emphysema
Blood aspiration
Haematoma
Oesophageal perforation

BREATHING AND MECHANICAL VENTILATION

Needle thoracocentesis for children with major trauma in the emergency department

Background

Traumatic injury may cause pneumothoraces. A high index of suspicion is required. A simple pneumothorax may become tensioned. In a spontaneously breathing patient this normally occurs relatively slowly – more than 45 minutes after initial injury. After starting positive pressure ventilation, tension can occur quickly – frequent reassessment of the patient is necessary.

Indications

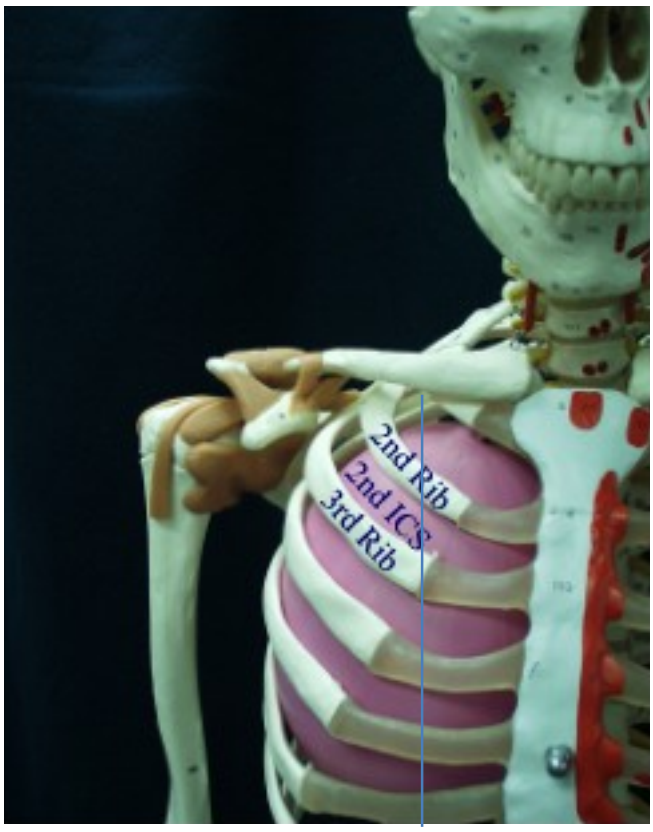
Suspected tension pneumothorax
Peri-arrest situation before moving to thoracostomy or chest drain insertion.

Equipment

Large bore cannula (14G in adolescents, 18G in children, 20G in neonates)
10ml syringe
Saline

Procedure of needle thoracocentesis

1) Administer high flow oxygen
2) Attach a 10ml syringe to the rear of the cannula and needle.
3) Identify the second intercostal space, mid-clavicular line on the side of the suspected tension pneumothorax, as shown on the diagram below.



4) Clean the skin and insert the cannula into the skin, just superior to the third rib. Aspirate on the syringe whilst advancing the cannula, withdrawal of air suggests entrance through the pleura into the pneumothorax.
5) Advance the cannula over the needle and remove the needle. A sudden escape of air may occur indicate the presence of a tension pneumothorax.
6) The cannula may need flushing, as it can occlude with a skin/fat/soft tissue plug.
7) Progress to thoracostomy and chest drain insertion on the side of the needle decompression.

Alternative procedure

1) An alternative location for the procedure described above is the 4th or 5th intercostal space, mid-axillary line.

Complications

Pneumothorax
Local haematoma/vascular injury
Lung laceration

Chest drain insertion for children with major trauma in the emergency department

Indications

Traumatic pneumothorax or haemothorax requires chest drain insertion. Chest drain insertion in children is only carried out under general anaesthesia.

Equipment

2% Chlorhexidine/70% alcohol
Scalpel with size 10 blade
Forceps
Portex thoracostomy tube and flutter valve/collection bag
Suture – prolene or silk
Occlusive dressing - tegaderm

Open procedure of chest drain insertion

1) Ensure child is anaesthetised and has received analgesia
2) Determine the insertion site – 4th or 5th intercostal space just anterior to the mid axillary line.
3) Determine the intended insertion length. For draining air, measure from the insertion point to the suprasternal notch. For draining blood, measure from the insertion point to the xiphisternum.
4) Clean the skin with 2% chlorhexidine/70% alcohol preparation. Wear sterile gloves and gown. Drape the chest.
5) Make a transverse incision at the pre-determined site, just over the top of the rib.
6) Bluntly dissect through the intercostal muscles and parietal pleura with straight forceps.
7) Put a gloved finger into the incision and sweep round to clear the lung. This may not be possible in small children.
8) Advance the proximal end of the chest drain tube into the pleural space to the length previously determined. For draining air, aim the drain towards the lung apex. For draining blood aim the drain towards the xiphisternum.
9) Connect the end of the drain to the flutter valve/collection bag.
10) Suture the chest drain tube in place. Use tape to secure the sutures to the tube.
11) Close incision with additional sutures if required and apply an occlusive dressing around the insertion site.
12) Obtain a chest X-ray to assess the chest drain position and its effect on lung inflation.

Complications

Injury to intra-thoracic organs – prevented by finger sweeping.
Introduction of pleural infection
Damage to intercostal nerve, artery or vein
Chest tube kinking/clogging, Subcutaneous emphysema

Management of rib fractures in children with major trauma

Rib fractures in children indicate a significant mechanism of injury and an expected underlying tissue injury. Thoracic vascular disruption, lung, spleen and liver injuries can occur underlying rib fractures.

Management of the child should aim to correct or support organ dysfunction, control pain and enable investigation and treatment.

In children with rib fractures and organ dysfunction, general anaesthesia enables control of oxygenation and ventilation, control of pain and appropriate radiological investigation.

Children with major trauma are always admitted to the paediatric intensive care unit, where further management of rib injuries can occur.

Subsequently, pain management for multiple rib fractures is managed in liaison with the paediatric pain team. Please see the analgesia section of the children's major trauma guidelines for details on analgesia for rib fractures.

Use of the Oxylog 3000 ventilator

1) Choose the correct ventilator for the child

The oxylog 3000 is suitable to ventilate children weighing more than 15kg. For children less than 15kg, use the babypac ventilator (see use of the babypac ventilator).

2) Ensure the required cables are attached to the oxylog 3000

Connect the black oxygen cable to the wall oxygen or a full CD oxygen cylinder using the Schraeder valve.

Ensure the pressure cable and ventilator tubing are connected to the oxylog 3000 body. There are 2 sizes of disposable ventilator hose – paediatric and adult. Paediatric hose (blue) is used for children weighing 15kg to 40kg. Above 40kg the adult hose (white) is used.

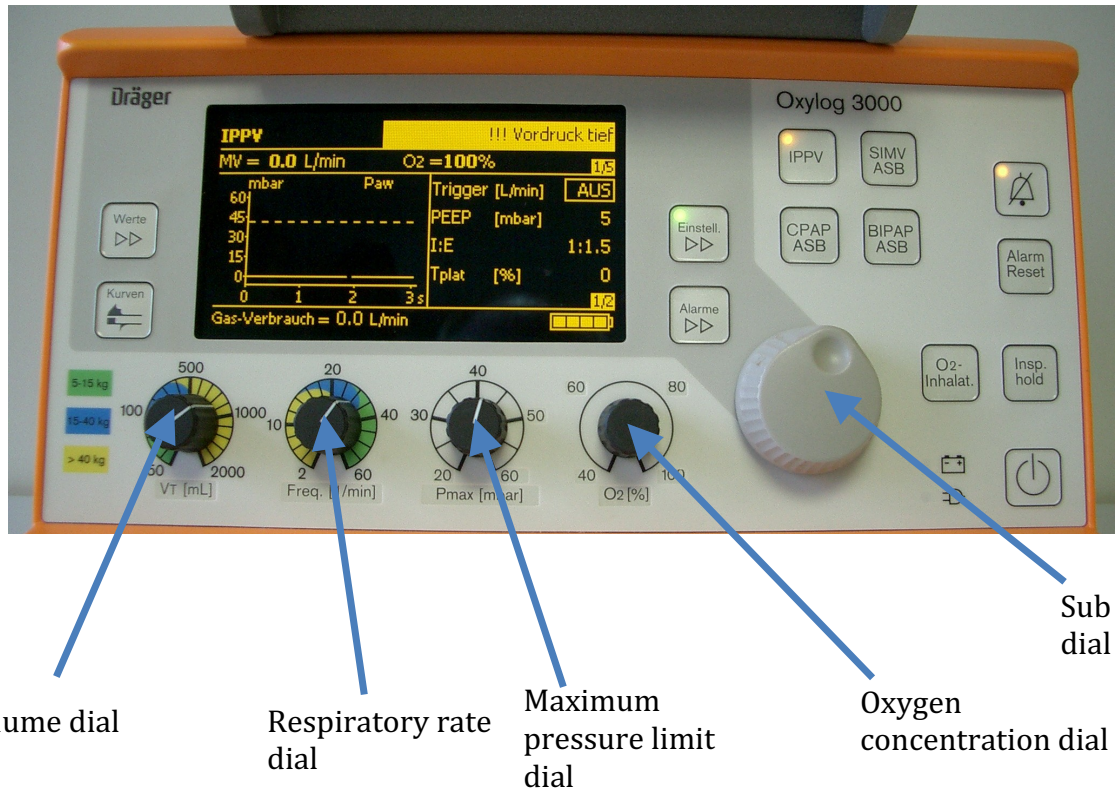
Paediatric disposable hose

Adult disposable hose

3) Turn the Oxylog 3000 ventilator on

Turn the oxylog 3000 on by pressing the  key.

4) Set the Oxylog 3000 to ventilate an anaesthetised and muscle relaxed child



Tidal volume dial

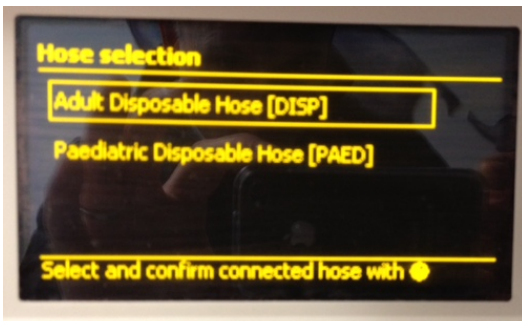
Respiratory rate dial

Maximum pressure limit dial

Oxygen concentration dial

Sub menu control dial

a) Choose the correct ventilator hose settings for the child



For children weighing 15kg to 40 kg, choose the paediatric disposable hose setting by rotating the sub menu control dial and clicking.

For children weighing more than 40kg, choose the adult disposable hose setting by clicking the sub menu control dial.

b) Choose IPPV mode by pressing the IPPV button.

c) Choose a tidal volume for your patient using the 'VT' dial.

A tidal volume of 5 to 8 ml/kg is normally required.

d) Choose a respiratory rate for your patient using the 'freq' dial

e) Set the maximum pressure limit to 30 cmH_20 using the 'Pmax' dial

f) Set the inspired oxygen concentration to 100% using the 'O2' dial

g) The positive end expiratory pressure (PEEP) applied to your patient can be altered using the sub menu control dial. Press the dial once and twist the dial to highlight the PEEP value on the screen then press the dial to select PEEP. Once selected the value can be altered by rotating the dial. To lock a value, press the dial once more.

5) Attach the ventilator to the catheter mount and attach to test lung

Attach the ventilator tubing to the catheter mount.

The catheter mount should be set up with a heat and moisture exchanger and filter (HMEF) and end tidal carbon dioxide monitoring, as per the picture below:

For children weighing 15 to 40kg – use a medium size HMEF (VT 75-200ml) and use the paediatric disposable oxylog 3000 circuit

For children weighing more than 40kg – use a large HMEF (VT 200-600ml) and use the adult disposable oxylog 3000 circuit.

6) Connect to the patient

a) Connect the catheter mount to the child's endotracheal tube.

b) Observe for the child's chest movement and end tidal carbon dioxide trace.

c) Adjust the ventilator settings according to patient need.

d) Change back to ventilating the child with a self inflating bag if no chest movement is obtained.

Use of the babypac ventilator

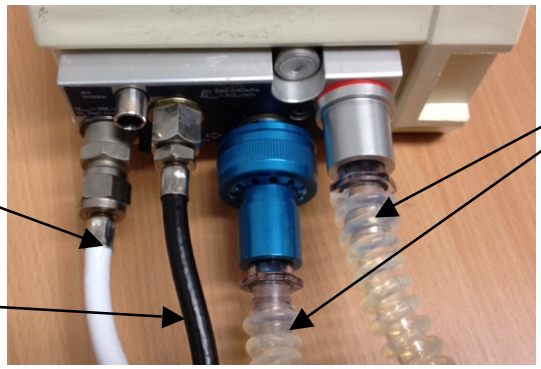
1) Choose the correct ventilator for the child

The babypac is suitable to ventilate children weighing less than 15kg. For children more than 15kg, use the oxylog 3000 ventilator (see use of the oxylog 3000 ventilator).

2) Obtain the babypac ventilator

The babypac ventilator is kept on PICU in an orange pack. Ring extension 4949 and ask for the babypac ventilator pack.

3) Ensure the required cables are attached to the babypac



Connect the white oxygen cable to the wall oxygen or a full CD oxygen cylinder using the Schraeder valve. The black air cable does not need to be connected to an air source for trauma patients. Ensure the ventilator tubing is connected to the babypac body.

Correct connection of oxygen is indicated on the front panel of the babypac, with a white ball becoming visible.

Oxygen not attached or not flowing

Oxygen attached and flowing

4) Set the dials on the babypac ventilator for a sedated and muscle relaxed child

These are starting settings and normally will require adjustment once the ventilator is ventilating the patient.

a) Set the pressure limit to 30cmH_20. This does not need to be altered from now on.

Pressure limit dial

b) Set the inspiratory time to 0.75 second. This does not need to altered from now on.

c) Set the expiratory time to 2 seconds. This gives a respiratory rate of 22.

d) Set the ventilator mode to 'CMV + ACTIVE PEEP', by turning the dial anti-clockwise. The ventilator will now begin cycling. Attach to a test lung.

e) Set the delivered oxygen to 100%

f) Set the PEEP to 5cmH_20. This position is half way through the white section of the dial. The actual PEEP delivered can be viewed on the pressure dial whilst ventilating the test lung.

h) Set the Peak inspired pressure to 20cmH_20. The pressure delivered can be viewed on the pressure dial whilst ventilating the test lung.

5) Test the ventilators function and alarms

a) Set the ventilator mode to 'CMV + ACTIVE PEEP', by turning the dial anti-clockwise. The ventilator will now begin cycling and all the alarm lights flash in turn. A single burst of the high priority audible alarm is given at the same time. The orange silenced indicator should flash for 60 seconds.

b) Check that flow is coming from the patient connection port by feeling the flow when placed close to the back of the hand or to the face.

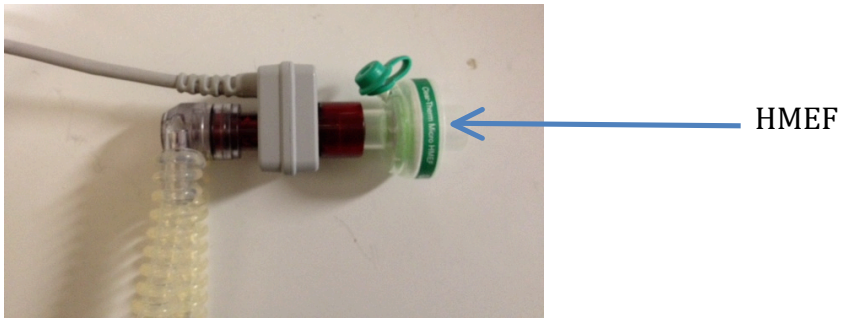
c) Occlude the proximal connection port of the patient circuit and check that the pressure dial gives a reading of between 15 and 25 cmH_2O during each inspiratory phase. The audible alarm should not sound.

d) Leaving the high pressure alarm setting at 30 cmH_2O, set the inspiratory pressure to 40 cmH_2O. Occlude the proximal connection port of the patient circuit and the pneumatic audible alarm should sound, accompanied by the high inflation pressure visual alarm. The pressure dial should read between 25 and 35 cmH_2O. After occlusion for one second, the high priority electronic audible alarm will also sound. Turn the inspiratory pressure back down to 20 cmH_20.

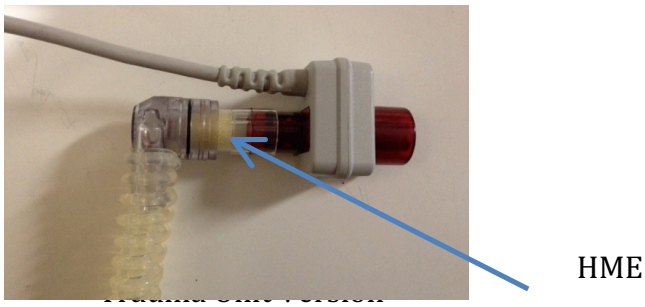
e) Allow the ventilator to cycle with no obstruction at the output port and check that the low inflation pressure (disconnect) alarm operates after 8 seconds.

6) Connect the babypac ventilator tubing to an HMEF and ETCO2

For children weighing 4kg to 15kg, connect the babypac ventilator circuit to the end tidal CO_2 adaptor and a small heat moisture exchanger and filter (HMEF), as shown in the picture below:



For children weighing less than 4kg, connect the babypac ventilator circuit to a heat moisture exchanger and end tidal CO_2 adaptor as shown in the picture below:



7) Connect to the patient

a) Connect the assembled ventilator circuit to the child's endotracheal tube.
b) Observe for the child's chest movement and end tidal carbon dioxide trace.
c) Adjust the ventilator settings according to chest movement, end tidal carbon dioxide monitoring and pulse oximetry.
d) Change back to ventilating the child with a self inflating bag if no chest movement is obtained.

CIRCULATION

Intra-osseous access in children with major trauma in the emergency department

Indications for use

Difficulty in obtaining intravenous access in a child needing vascular access.
First line for vascular access in arrested children.

Equipment

Kept in children's circulation trolley in the emergency department
a) EZ-IO drill driver
b) Blue needle for children weighing more than 40kg
c) Pink needle for children weighing 5kg to 39kg
d) Forceps
e) Tape

Procedure of inserting intra-osseous access in the tibia

1) Locate the tibial tuberosity on the anterior aspect of the tibia. The insertion site for IO access is 1 finger breadth below the tibial tuberosity. Clean the skin overlying the tuberosity.

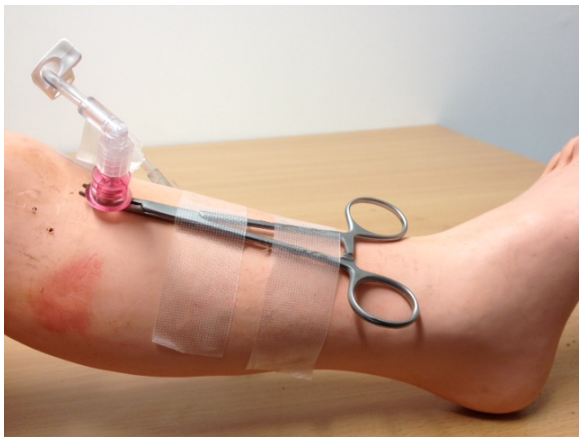
2) Stabilize the shin and place the EZIO drill with appropriate needle at 90 degrees to the insertion site.

3) Lightly hold the driver in your dominant hand and press the driver button. Gently guide the needle into the bone. Do not press hard, allow the driver to do the work. Carefully feel for the "pop" or "give" indicating penetration into the medullary space. STOP - WHEN YOU FEEL THE give.

4) Stabilise the needle and remove the central stylet. The needle should be firmly seated and stand unsupported.

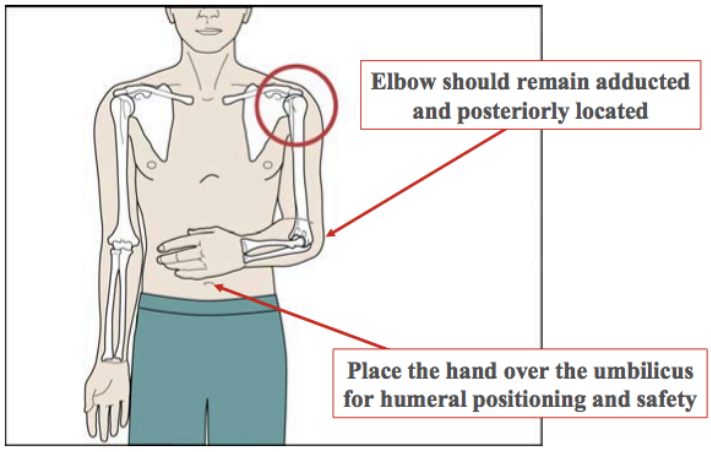
5) Connect the extension set and withdraw bone marrow to assess location. Flush the IO needle, easy flow and no extravasation suggest correct location.

6) Fix the IO needle with a pair of forceps and tape the forceps to the shin.

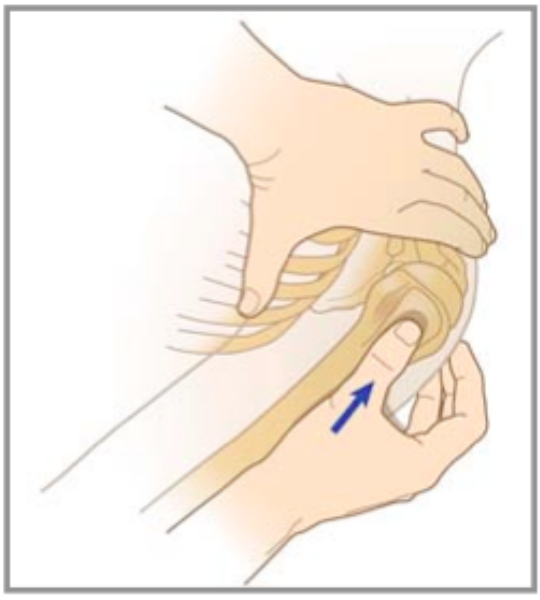


Procedure of inserting intra-osseous access in the humerus

1) With the child in the supine position, place the patients hand on their umbilicus. This causes the humerus to internally rotate.

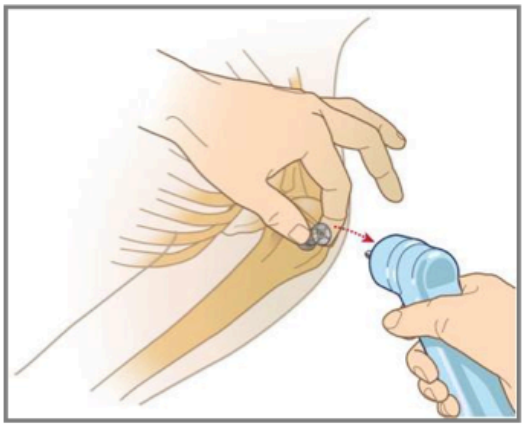


2) Palpate and identify the mid-shaft humerus and continue palpating toward the proximal aspect or humeral head. As you near the shoulder you will note a small protrusion. This is the base of the greater tubercle and is the insertion site for IO access. Clean the skin overlying the tubercle.

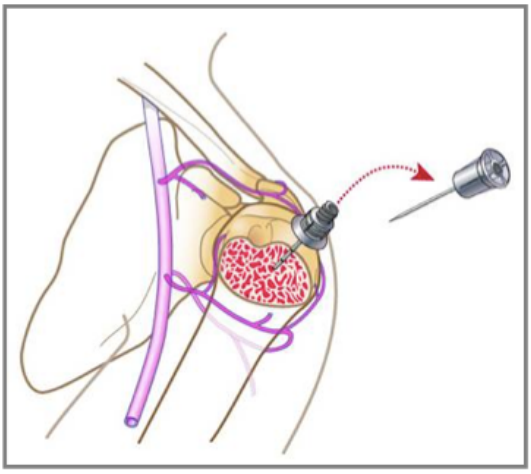


3) Stabilize the arm and place the EZIO drill with appropriate needle at 90 degrees to the insertion site.

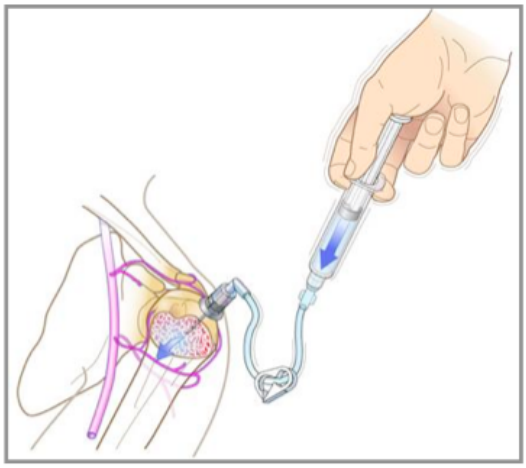
4) Lightly hold the driver in your dominant hand and press the driver button. Gently guide the needle into the bone. Do not press hard, allow the driver to do the work. Carefully feel for the "pop" or "give" indicating penetration into the medullary space. Stop - when you feel the give.



5) Stabilise the needle and remove the central stylet. The needle should be firmly seated and stand unsupported.



6) Connect the extension set and withdraw bone marrow to assess location. Flush the IO needle, easy flow and no extravasation suggest correct location.



7) Fix the IO needle with a pair of forceps and tape the forceps to the arm.

Contra-indications to IO insertion

a) Fracture of target bone
b) Previous IO in same bone in previous 24 hours
c) Infection at insertion site
d) Inability to locate landmarks

Children's major haemorrhage guideline

Introduction

Massive Transfusion has a number of retrospective definitions looking at blood product requirement over the preceding 24 hours; none of which guide immediate management of massive haemorrhage.

A volume requirement associated with trauma of more than 20ml/kg in the first hour of treatment is massive haemorrhage. Such blood loss is rare in children's trauma, which increases the need for protocolised therapy.

In children with major trauma, hypoperfusion, hyperfibrinolysis, activation of protein C and up-regulation of thrombomodulin pathways all contribute to an Acute Coagulopathy of Trauma Shock (ACoTS). Aggressive treatment of the lethal triad of hypothermia, acidosis and coagulopathy is essential to countering ACoTS. The combination of these treatment strategies is termed **Damage Control Resuscitation (DCR).** Damage control resuscitation (DCR) and damage control surgery (DCS) are now well recognised in military and civilian trauma practice.

Management principles

1) Control of massive haemorrhage

- Control massive external haemorrhage with direct pressure and elevation, pressure dressings, haemostatic gauze or tourniquets
- Search for sources of internal haemorrhage in the chest, abdomen, pelvis and femori. In children with a patent fontanelle (generally less than 18 months old), consider intracerebral haemorrhage.
- Use a pelvic sling/binder to splint suspected pelvic fractures.

2) Control of the airway

- In the presence of massive haemorrhage a definitive airway (cuffed endotracheal tube) is mandatory.

3) Vascular access

- Intra-osseous (IO) access is suitable if peripheral IV access is poor, inaccessible or delayed.
- In lower limb, pelvic or abdominal trauma, beware of use of lower limb venous access – as infused products may simple be lost through damaged vessels.
- Take baseline blood samples on admission for blood group and X-Match, venous blood gas including ionized calcium and glucose, full blood count, urea and electrolytes, lactate, coagulation including fibrinogen.
- Do not delay medical or surgical treatment to obtain arterial access.

4) Massive transfusion guideline used at Southampton Children's Hospital (This may be different in your Trauma Unit)

- Initial resuscitation is aimed at normalisation of physiology and control of haemorrhage.
- Informing haematology of a 'paediatric code red' request for a major trauma patient will result initially in: a Pack of 20ml/kg of O RhD negative packed red cells and 20ml/kg of thawed AB Octaplas (FFP96) (unless the blood group is known).
- Manage major trauma proactively with boluses of 5-10ml/kg of **warmed** Octaplas (FFP96) and **warmed** packed red cells. Aim for equal volumes of infused packed cells and Octaplas (FFP96) (1:1 ratio).
- Change to type-specific blood components as soon as available.
- Ensure the availability of platelets and aim to the keep platelet count above 75 x 10^9/l. Provide a dose of platelets after every 20ml/kg of packed cells transfused. For children weighing less than 15kg, the platelet dose is 10ml/kg. In children weighing more than 15kg, the dose is 1 adult therapeutic pack of platelets.
- Give 15mg/kg of tranexamic acid as soon as possible, if within 3 hours of injury.
- Aim for a palpable radial pulse or a systolic blood pressure of no more than 90mmHg until haemorrhage is controlled.
- Avoid vasoconstrictors in the early resuscitation period and instead use blood products to support blood pressure.
- Further resuscitation should be guided by repeat FBC, base deficit/lactate clearance and RoTeM thromboelastography (Goal directed Therapy) where available.
- After 40ml/kg of blood products consider administering 10ml/kg of cryoprecipitate to provide fibrinogen.

5) Biochemical management

- Hypocalcaemia management.

Calcium levels are frequently low in major trauma and associated with worsening clotting and mortality. Give 0.1ml/kg of 10% Calcium Chloride every 20ml/kg of blood products or if ionised calcium level is less than 1.0mmol/l on blood gas analysis. Or 0.1mmol/kg (0.5ml/kg) of Calcium Gluconate could be used to correct the hypocalcaemia instead.

- Hyperkalaemia management.

Potassium levels can rise to dangerous levels quickly. Use a bolus of 10mls/kg of 10% Dextrose and 0.1 units/kg of insulin actrapid to maintain potassium below 6 mmol/l.

Point of care blood gas equipment allows frequent blood sampling and facilitates the evolving resuscitation.

6) Hypothermia management

- Essential to keep temp >36°C to reduce coagulopathy
- Use an oesophageal temperature probe in unconscious patients
- Fluid warming is the first priority – ranger or Belmont device
- Under patient mattress warmer
- Forced warm air blankets (bair hugger)
- Warm humidified breathing circuit

- Hat

7) Patients born after 1996 and precautions against the transmission of vCJD

- In order to minimise the risk of transmitting new variant CJD, patients who are born after January 1996 should receive pathogen reduced FFP and cryoprecipitate sourced from outside the UK.
- This would either be methylene blue or solvent detergent treated FFP (octoplas) and cryoprecipitate.
- The rationale for this cut off date is that children born since 1996 are considered to have received minimal exposure to the BSE agent because of the effectiveness of the animal feed ban which was fully implemented from 1996 and the exclusion of animals above 30 months entering the food chain.

Wessex children's major trauma guidelines

This is currently used at Southampton Children's Hospital but may differ in Trauma Units.

Paediatric Major Haemorrhage Protocol – CODE RED

ACTIVATION – Senior Clinician

Suspected major haemorrhage
HR> normal range, BP< normal range, absent radial pulse or poor organ perfusion
No alternative cause for hypotension

ACTION

1. Allocate **Code Red** practitioner – direct communication with blood transfusion service, give **age/weight** of child to blood bank
2. Send baseline investigations; FBC, G+S, Coag, U+E, glucose + VBG/ABG.
3. Give Tranexamic acid 15mg/kg IV
4. Call on-call haematology registrar/consultant for advice and on-going decision support (bleep 9145 9am-5pm weekdays or via switchboard out of hours)

REQUEST
MAJOR HAEMORRHAGE PACK 1

1. Immediate blood transfusion (O –ve from nearest fridge or units from lab)
2. FFP96 (Octoplas) – up to 40 mins thawing time (type A until group specific available)
3. Give 5ml/kg boluses of RBCs or FFP96 and re-assess after each bolus (aim for 1:1 ratio)

REQUEST
MAJOR HAEMORRHAGE PACK 2

1. Blood (O –ve until group/type specific available) + FFP96
2. 1 pooled unit of platelets – give 10ml/kg after 20ml/kg of RBCs
3. Give 5ml/kg boluses of blood or FFP96 and re-assess after each
4. Give 10ml/kg of cryoprecipitate if fibrinogen <2g/l

ONGOING BLEEDING

1. Alternate pack 1 & pack 2 until bleeding controlled – use thromboelastography to guide haemostatic resuscitation where available
2. Discussion with a Haematologist to consider use of rFVIIa (if no reversible surgical cause, platelets > $75x10^9$/l + fibrinogen >2g/l)

AIMS OF TRANSFUSION (NB Monitor lab tests closely)
Hb ≥ 80g/L
Platelets ≥ 75×10^9/L
INR and APTR ≤ 1.5
Fibrinogen ≥ 2g/L
iCa^{2+} ≥ 1.0 mmol/L
Temperature ≥ 35°C pH ≥ 7.2 Lactate ≤ 4 mmol/L

PACK 1		
Age/Wt	**RBC Units**	**FFP96**
0-2 yrs/≤ 11 kg	1	1
3-8 yrs/12-25kg	2	2
9-15 yrs/25-40kg	3	3
>16 yrs/>40kg	6	4

PACK 2				
Age/Wt	**RBC Units**	**FFP96**	**Cryoprecipitate**	**Platelets**
0-2 yrs/≤ 11 kg	1	1	1-2 baby packs	1
3-8 yrs/12-25kg	2	2	3 baby packs	1
9-15 yrs/25-40kg	3	3	1 standard pack	1
>16 yrs/>40kg	6	4	2 standard packs	1

Suggested constituents of major haemorrhage packs

These blood packs are supplied by blood bank according to the age or weight of the child. This may vary depending on your hospital.

Major haemorrhage pack 1

	Childs age or weight			Adult code red
	0 to 2 years 0 to 11kg	3 to 8 years 12 to 25kg	9 to 15 years 25 to 40kg	16 years and above More than 40kg
Units of packed red cells supplied	1	2	3	6
Units of Octaplas (FFP96) supplied	1	2	3	4

Major haemorrhage pack 2

	Childs age or weight			Adult code red
	0 to 2 years 0 to 11kg	3 to 8 years 12 to 25kg	9 to 15 years 25 to 40kg	16 years and above More than 40kg
Units of packed red cells supplied	1	2	3	6
Units of Octaplas (FFP96) supplied	1	2	3	4
Units of platelets supplied	1	1	1	1
Units of cryoprecipitate supplied	1-2 Baby packs*	3 Baby packs*	1 Adult pack**	2 Adult packs**

* Baby pack contains 35-40mls per pack

** Standard adult pack contains 280-300mls per pack

Children's traumatic haemorrhagic shock check list

Action point	Completed?	Time
Haemostatic dressings and limb tourniquets, if appropriate		
Sources of bleeding searched for in chest, abdomen, pelvis, long bones		
Plan for haemorrhage control – surgical, interventional radiology		
2 x vascular access IV or IO		
Tranexamic acid - 15mg/kg		
Bair hugger		
Warmed 0.9% sodium chloride 5ml/kg	**1.**	
	2.	
Warmed Packed Red Cells 5ml/kg	**1.**	
	2.	
	3.	
	4.	
	5.	
	6.	
	7.	
	8.	
	9.	
	10.	
	11.	
	12.	
Warmed Octaplas (FFP96) 5ml/kg	**1.**	
	2.	
	3.	
	4.	
	5.	
	6.	
	7.	
	8.	
	9.	
	10.	
	11.	
	12.	
Warmed Cryoprecipitate 10ml/kg	**1.**	
	2.	
	3.	
Calcium chloride 10%, 0.1ml/kg	**1.**	
	2.	
	3.	
Platelets 10ml/kg	**1.**	
	2.	
	3.	

Warming fluids given to severely injured children

Fluid boluses (saline or blood products) given to injured children should be warmed.
Warming can be achieved simply through external plate warming devices such as 'ranger fluid warmer' or through rapid infusor devices. The choice of device depends on the patient's size.

Choice of warming device
Rapid infusion devices commonly have a minimum volume delivery. The Belmont rapid infusor delivers a minimum of 100ml of warmed fluid. Therefore, working on a 5ml/kg delivery volume, the Belmont should be used for children weighing greater than 20kg.
External plate warming devices require fluid to be passed between 2 warm plates prior to entering the patient. The amount of fluid delivered is entirely controlled by the operator manually, making it ideal for smaller volume infusions. The 'ranger' fluid warmer is a commonly available device which can be used with a high flow 'ranger' warming set to deliver rapid boluses of fluid.

	Warming device	Additional notes
Child greater than 20kg	Belmont rapid infusor	Careful observation of vascular access site for features of tissuing.
Child less than 20kg	Ranger fluid warmer	Use a high flow warming circuit. Use a pressure bag to assist drawing up through syringe.

Using the ranger device to deliver warmed fluid
1) The 'ranger' high flow giving set is placed into the slot in the front of the ranger.
2) 0.9% sodium chloride is spiked with a blood giving set and then attached to the ranger giving set. The saline can then be used to run through the whole giving circuit. Ensuring it is free of air. The circuit is then clamped.
3) The fluid to be delivered to the patient is then spiked onto the circuit replacing the saline bag. A pressure bag is inflated around the fluid bag to assist in driving fluid through the warming circuit.
3) A three way tap is added at the patient end of the circuit and then the circuit (still clamped) is attached to the patient's intravenous or intra-osseous access.
4) A 50 ml syringe can be used on the three way tap to repeatedly draw fluid through the warmer and then push the fluid into the patient using the syringe. The 50 ml syringe delivery enables accurate volume fluid boluses to be delivered.

Tranexamic acid use in children's major trauma

A dose of 15mg/kg of tranexamic acid (TXA) should be given to all injured children with suspected or confirmed major haemorrhage.
This dose should be delivered as soon as possible and within 3 hours of the original injury. It can be given by intravenous or intra-osseous routes.

Initial dose of tranexamic acid

15mg/kg (maximum 1g) tranexamic acid diluted into 20ml 0.9% sodium chloride and delivered over 10 minutes.

On-going infusion of tranexamic acid

Children with ongoing bleeding should continue to receive an infusion of tranexamic acid at a rate of 2mg/kg/hour. The infusion should be continued until bleeding stops or for 8 hours whichever is sooner.
The infusion can be made up with 16mg/kg of tranexamic acid in 20ml 0.9% sodium chloride and delivered at a rate of 2.5ml/hour for up to 8 hours.

Traumatic cardiac arrest in children

1. Aims

To optimise the approach to the management of traumatic cardiac arrest.

2. Background

In traumatic cardiac arrest, prompt reversal of hypoxia, hypotension and aggressive management to treat tension pneumothoraces, evacuate a cardiac tamponade and arrest external or internal catastrophic haemorrhage is paramount to improving chance of survival.

3.1 Airway Management

All traumatic cardiac arrest patients should be intubated without anaesthetic drugs, however if Return of Spontaneous Circulation (ROSC) occurs anticipate the need for intravenous sedation, analgesia and muscle relaxation.

Waveform capnography should be used to confirm tracheal tube placement, to assess the effectiveness of resuscitation, and to inform prognosis.

3.2 Respiratory Management

Bilateral open thoracostomies should be made. Needle thoracocentesis may be performed initially for expediency but these should not be considered to provide definitive pleural decompression.

Inadequate peripheral perfusion precludes reliable pulse oximetry so this monitoring may be omitted initially.

3.3 Circulatory Management

Obvious external haemorrhage should be arrested with appropriate combinations of elevation, compression, pressure dressing, and tourniquet use.

Obvious long bone or pelvic disruption should be splinted.

A 10ml/kg intravenous or intraosseous fluid bolus should be given followed by re-assessment of pulses. Blood is the resuscitation fluid of choice. More fluid may be given if there is no return of spontaneous circulation (ROSC), titrated to the presence of a palpable radial pulse (blunt trauma) or carotid pulse (penetrating trauma).

In pulseless electrical activity or in the presence of obvious thoracic trauma, external cardiac compressions may be omitted at the discretion of the treating physician, since the theoretical mechanisms of action of this intervention are unlikely to be useful in these scenarios.

A clamshell thoracotomy could be considered at the clinicians discretion to occlude the descending aorta to stem blood flow and downstream

haemorrhage inferior to the diaphragm and if necessary providing internal cardiac massage.

3.4 Drug therapy

There is no evidence that intravenous drugs such as adrenaline improve survival from traumatic cardiac arrest, but there is an association between vasopressor use and worse outcome in major trauma patients. Intravenous adrenaline may therefore be omitted.

3.5 Beginning & discontinuing resuscitation

Resuscitation need not be attempted on patients with clearly unsurvivable injuries or who on examination are unequivocally dead. If there is doubt as to the timing of cardiac arrest, resuscitation should be commenced while a more thorough historical and physical assessment is made.

Cessation of resuscitation attempts is appropriate if there is no response to therapy.

3.6 Special Circumstances

3.6.1 Adults and children

The therapeutic priorities during traumatic cardiac arrest are the same in children as in adults.

3.6.2 The pregnant patient

Patients in the second half of pregnancy (uterine fundus above the umbilicus) should be resuscitated in the left lateral tilt position at least 30 degrees to minimise uterocaval compression; a scoop stretcher with blankets under the scoop enables this.

Survival of both mother and baby may be dependent on resuscitative hysterotomy being undertaken within four minutes of arrest with maternal survival improved with this procedure even after this time period.

3.6.3. Penetrating trauma

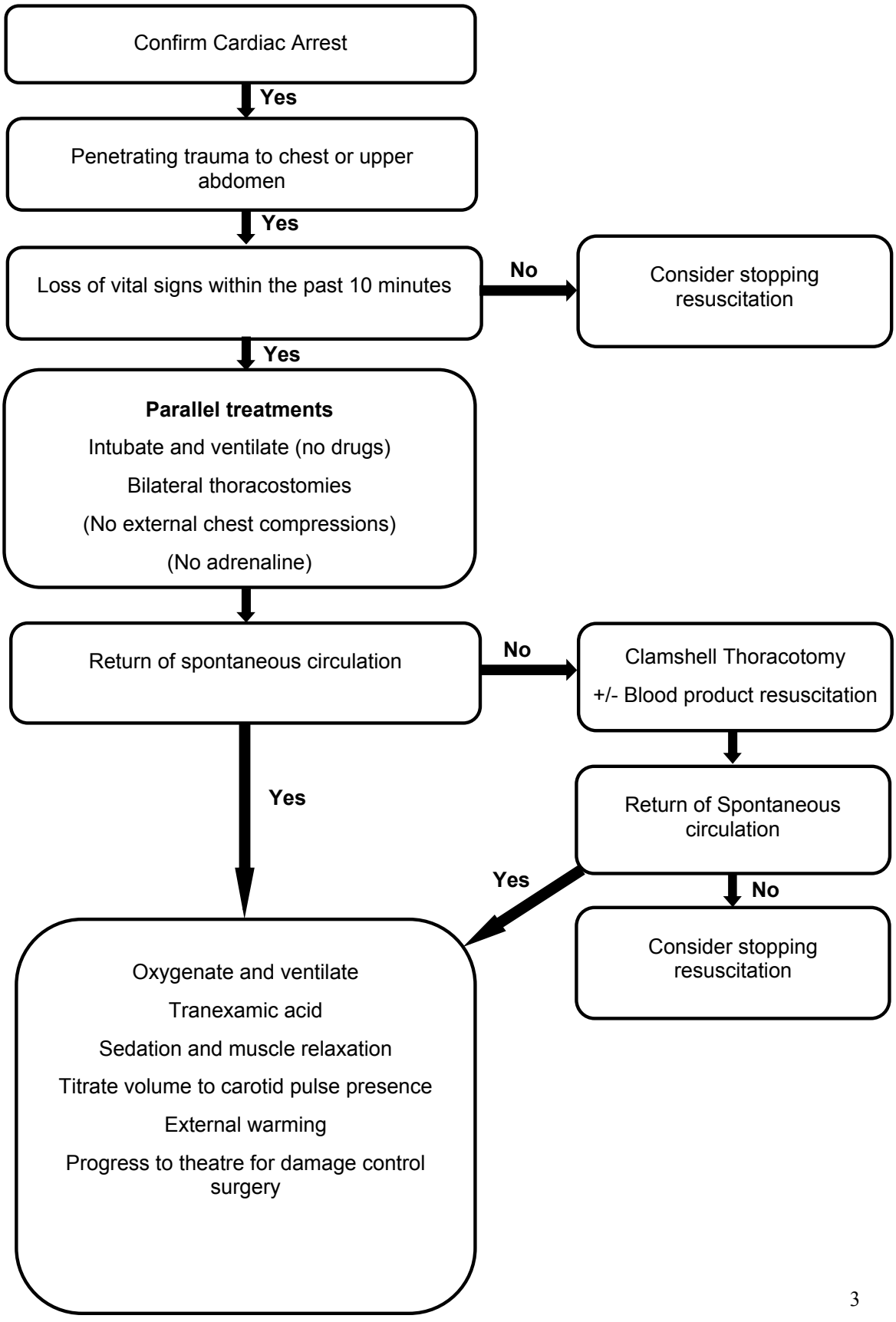
Thoracic or upper abdominal penetrating injury resulting in cardiac arrest should initially be managed as in 4.1.1 and 4.2.1 above.

If there is no ROSC a clamshell thoracotomy should be made with the specific purpose of relieving cardiac tamponade, controlling a cardiac wound(s), and if necessary providing internal cardiac massage.

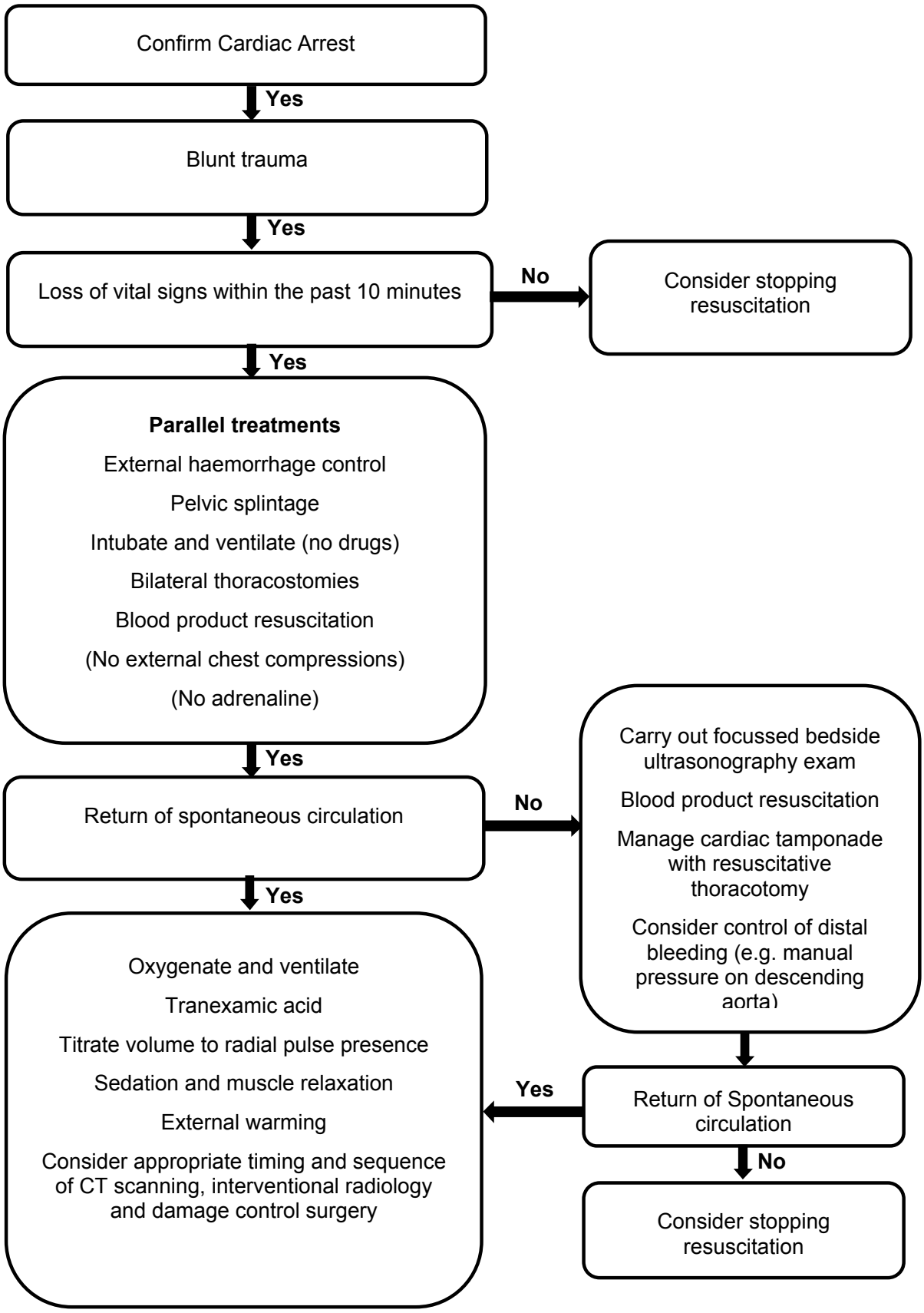
3.7 Debrief

Multi-professional debrief following resuscitation in traumatic cardiac arrest should ideally be carried out.

Penetrating traumatic cardiac arrest actions (all ages)



Blunt traumatic cardiac arrest actions (all ages)



Clam shell thoracotomy for children with traumatic cardiac arrest in the emergency department

Background

Cardiac arrest after penetrating chest trauma may be an indication for emergency thoracotomy. A successful outcome is possible if the patient has a cardiac tamponade and the definitive intervention is performed within 10 minutes of loss of cardiac output. The best prospects for success are for stab wounds in which the patient arrests in the presence of clinicians.
Wherever possible a patient with vital signs needing surgery for penetrating chest trauma should be moved to cardiothoracic theatre as rapidly as possible, where optimal surgical expertise and facilities are available. However, this is not an option if the patient is in cardiac arrest in the emergency department.
It is important to have a realistic expectation of what can be achieved by emergency thoracotomy. The procedure tackles a single pathology—cardiac tamponade with a controllable wound in the heart. If the underlying injury is any more complex than this a good outcome is unlikely outside of a fully equipped cardiothoracic theatre with cardiopulmonary bypass facilities.

Indications for clam shell thoracotomy

Penetrating chest/epigastric trauma associated with cardiac arrest (any rhythm).

Contraindications for clam shell thoracotomy

Definite loss of cardiac output for greater than 10 minutes.

Equipment

Thoracotomy
Scalpel with size 10 blade
Forceps
Heavy scissors

Haemostasis
Suture on needle – silk or prolene, size 1/0
Foley catheter
Forceps x 4

Procedure of clam shell thoracotomy

1) The procedure is carried out immediately within the emergency department, by the major trauma team. Call for cardiothoracic registrar and consultant attendance. If the procedure is successful then the cardiothoracic team will continue the child's care into theatre.

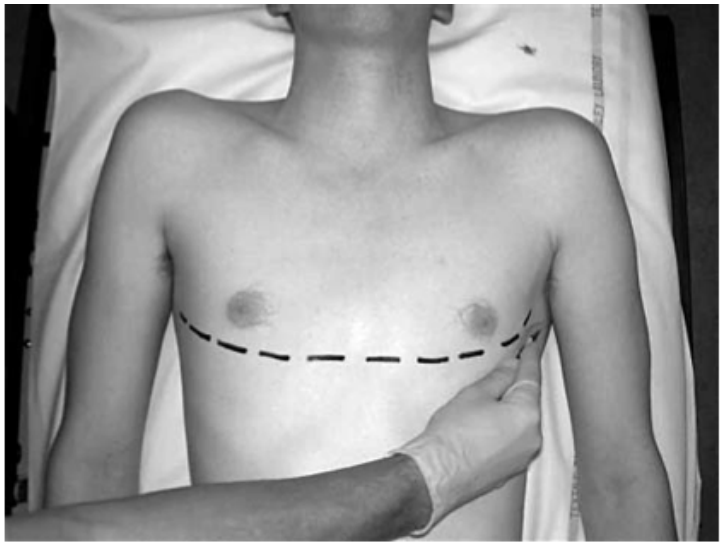
2) Intubation, ventilation, intravenous/intra-osseous access, should be performed by members of the trauma team and not delay the thoracotomy.

3) Time should not be wasted on full asepsis but a rapid application of skin preparation such as 2% chlorhexidine/70% alcohol preparation.

4) Using a scalpel and blunt forceps make bilateral thoracostomies (breaching the intercostal muscles and parietal pleura) in the 5th intercostal space in the mid- axillary line.

5) The procedure is stopped at this point if tension pneumothorax is decompressed and cardiac output returns.

6) Connect the thoracostomies with a deep skin incision following the 5th intercostal space (fig 1). Ensure the incision extends posteriorly bilaterally to the posterior axillary line – this allows adequate access when opening the clamshell.



A skin incision following the 5th intercostal space is made between the posterior axillary lines.

7) Insert two fingers into a thoracostomy to hold the lung out of the way while cutting through all layers of the intercostal muscles and pleura towards the sternum using heavy scissors following the skin incision previously made. Perform this on left and right sides leaving only a sternal bridge between the two anterolateral thoracotomies.

8) Cut through the sternum or xiphoid using the heavy scissors.

9) Open the ‘‘clam shell’’ using one or two gloved assistants. If exposure is inadequate the incisions need to be extended posteriorly.

10) Lift (‘‘tent’’) the pericardium with forceps and make a large midline longitudinal incision using scissors. This approach minimises the risk of damage to the phrenic nerves, which run in the lateral walls of the pericardial sac. Making the incision too short will prevent full access to the heart.

11) Deliver the heart out of the pericardium and evacuate all blood and clot present, then inspect the heart rapidly but systematically for the site of bleeding.

12) One of three scenarios are now likely:
(a) The heart will begin to beat spontaneously with a return of cardiac output. In this situation any cardiac wounds should be closed as described below.

(b) The heart begins to beat slowly with a considerably reduced cardiac output. In this situation wounds should be closed quickly, then attempt to improve coronary and cerebral perfusion by partially/completely occluding the descending aorta manually as low as possible (fist against the spine) to achieve cross clamping - this can be done by an assistant if necessary. Provide supplementary internal cardiac massage and volume resuscitation with blood products.

(c) The heart remains in asystole. In this case wounds should be quickly closed and then attempts made to restart the heart as in step 10b. Simply flicking the heart may produce a return of contractions.

(d) If there is evidence of significant blood loss, cardiac wounds should be closed and manual occlusion of the aorta should be carried out whilst undertaking volume expansion. The descending thoracic aorta should be occluded/compressed/clamped as low as possible – this can be most easily achieved compressing the aorta with a closed fist against the vertebral bodies.

13) When internal cardiac massage is required it must be of optimal quality. One flat hand is applied to the posterior surface of the heart and one on the anterior surface. Blood is ‘‘milked’’ from the apex upwards at a rate of 80 beats per minute. Avoid single handed cardiac massage as there is a significant risk of the operators thumb perforating the right ventricle. Ensure that the heart remains horizontal (in the anatomical intra-pericardial position) during massage. Lifting the apex of the heart impairs venous filling.

14) Control any bleeding:
a) Holes in the myocardium less than 1 cm can usually be occluded temporarily using a finger or gauze swab. If this is successful no other method should be attempted.

b) For larger defects, a Foley urinary catheter can be passed through the hole then inflated and gently pulled back. This technique reduces the volume of the ventricular cavity (with subsequent reduction in stroke volume) therefore only a small volume (less than 10 ml) should be used in the balloon. Ensure that the catheter is clamped to prevent blood loss from it. If a catheter is used in this way, a ‘‘giving set’’ can be attached to permit rapid volume infusion

directly into the heart. Take care to avoid air embolism and ensure that the Foley catheter does not get 'avulsed' when the patient is moved.

c) If bleeding cannot be controlled with finger/Foley catheter, it may be necessary to close the defect with large sutures, but it should be emphasised this is a last resort as there is a risk of occluding coronary arteries. If sutures are used the minimum required to achieve haemostasis facilitated by finger/Hemcon/Foley catheter should be used; take 1cm ''bites'' – do not do this with wounds close to the right AV grove or in close proximity to (proximal) coronary arteries.

15) If defibrillation is required. Use the internal defibrillation paddles and 0.5J/kg shock.

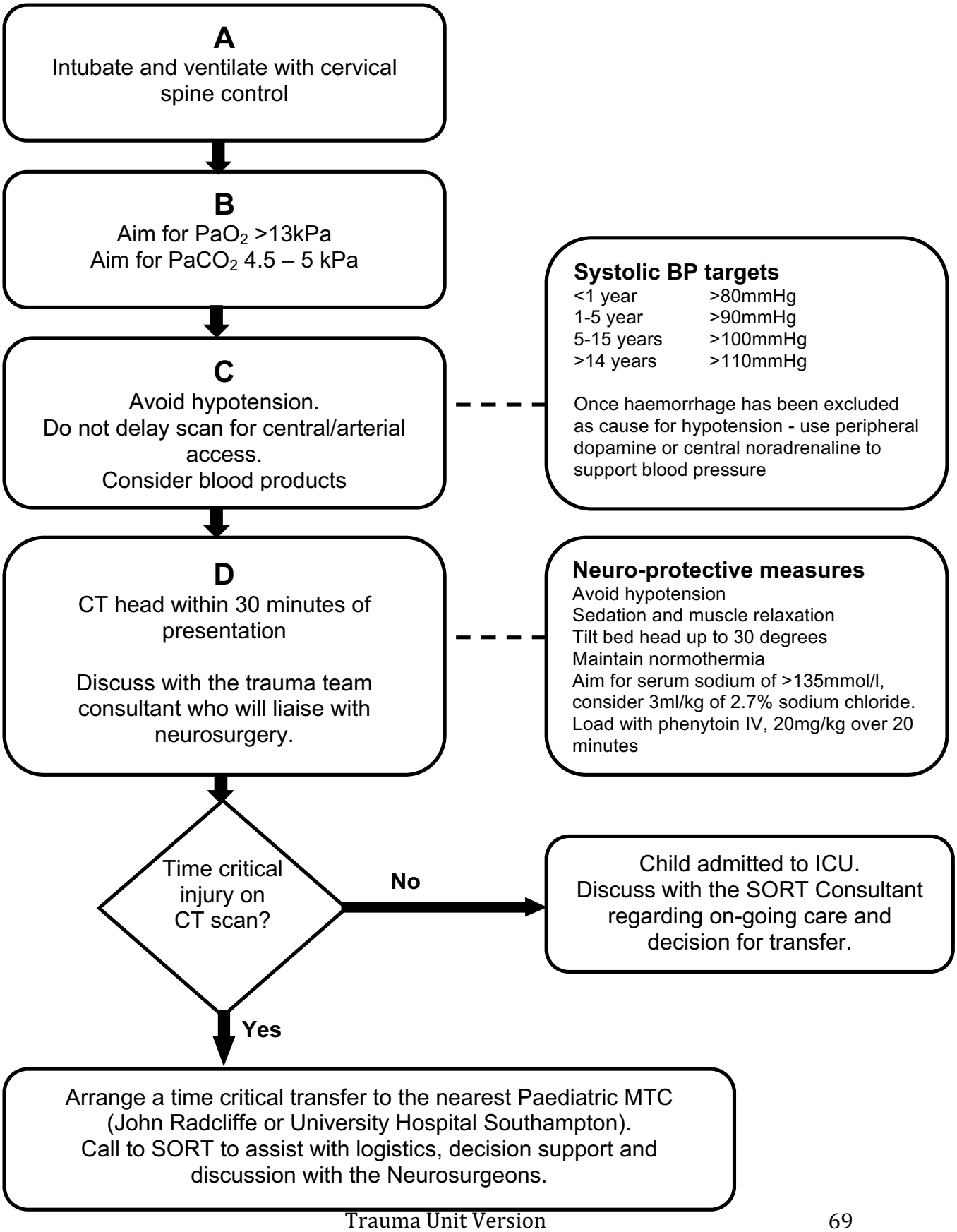
16) If the procedure is successful the patient may begin to wake up so be prepared to provide immediate anaesthesia.

17) Restoration of circulation may be associated with bleeding, particularly from the internal mammary and intercostal vessels. Large bleeders may be controlled with artery forceps.

18) Once perfusion has been restored the patient should be moved to a cardiothoracic theatre for definitive repair.

HEAD, SPINAL and EYE INJURIES

Pathway for the initial management of severe traumatic brain injury in children (GCS 8 or less)



Guideline for the initial management of severe traumatic brain injury in children (GCS 8 or less)

Introduction

Severe traumatic brain injury is classified as a Glasgow Coma Scale (GCS) 8 or less. This GCS must be a post-resuscitation, and must not be post-ictal. Severe traumatic brain injury (TBI) is the leading cause of death in children in the UK, accounting for 15% of deaths in 1-15 year olds and 25% of deaths in 5-15 year olds. The most common cause is pedestrian versus car road traffic accidents followed by falls. In infancy, non-accidental injuries remain an important cause.

The aims of management are to prevent secondary damage/injury by the prevention of hypoxia, hypotension, and raised intracranial pressure (ICP).

If CT imaging identifies a time critical lesion (e.g. extradural haematoma with mass effect) requiring urgent neurosurgical intervention then the patient requires rapid transfer by the local team to the paediatric neurosurgical centre.

Priorities:

- **Stabilize Airway, Breathing and Circulation before attending to other injuries.**
- **Facilitate rapid, safe CT head to enable identification of time critical brain injury.**
- **Discuss the patient early with the SORT PICU consultant.**

1. Airway

1. All children with a GCS of 8 or less must be intubated and ventilated.
2. Spinal immobilisation before, during and after intubation is essential. Intubation of these patients therefore requires a minimum of 4 people to manage the process (in-line immobilisation, cricoid pressure, intubator, assistant).
3. Ketamine & rocuronium – are the agents recommended for induction and muscle relaxation, unless contra-indicated.
4. Once intubated all patients must be adequately sedated with morphine & midazolam and muscle relaxation maintained (e.g. with rocuronium boluses).

2. Spinal protection

1. All patients with severe traumatic brain injury should have their cervical spine immobilised either with a) manual in line stabilisation (MILS) or b) with blocks and tape.
2. Cervical spine immobilisation should be achieved with manual in line stabilisation during intubation.
3. Log roll should be used if turning the patient for any reason to protect the cervical, thoracic and lumbar spine.

4. The duration that the patient is on a hard spinal board should be minimised; this is to avoid pressure sores. Spinal boards are a pre-hospital device used to assist extrication of patients from damaged vehicles. Patients should not be transferred around the hospital on spinal boards.
5. A scoop stretcher is an acceptable device to transfer patients on.

3. Ventilation

1. All patients should be adequately sedated (morphine & midazolam) & muscle relaxed (e.g. rocuronium boluses) for transfer. Drug doses and ranges are provided in section 8.
2. All patients must have end-tidal carbon dioxide (CO_2) monitoring.
3. Patients should be ventilated to an end tidal carbon dioxide level that correlates to a blood carbon dioxide level ($PaCO_2$) of 4.5-5 kPa. Blood samples for blood gas analysis may be venous, capillary or arterial.
4. Provide oxygen to maintain saturations ≥98% or an arterial PaO_2 >13kPa.
5. Ventilate all patients with positive end expiratory pressure (PEEP) of at least 5 cmH_20.

4. Circulation

1. Every patient should have a minimum of 2 large bore peripheral cannulae or intraosseous needles.
2. Blood should be taken for cross match, blood sugar, blood gas, urea and electrolytes, full blood count, coagulation.
2. Treat hypotension aggressively. Hypotension is the biggest cause of secondary ischaemic injury
3. Maintain **systolic** blood pressure above 95th centile for age, this is to ensure adequate cerebral perfusion pressure:

<1 year	>80mmHg
1-5 year	>90mmHg
5-14 year	>100mmHg
>14year	>110mmHg

4. **Do not delay CT for insertion of central and arterial access.**
5. Consider resuscitation with blood products early in haemorrhagic shock (see massive haemorrhage guideline).
6. If cardiovascularly unstable despite fluid resuscitation, it is vital to reconsider sites of bleeding – these can be onto the floor (external haemorrhage), into the chest, into the abdomen, into the pelvis or into the femur. In infants with an open fontanelle, intracranial haemorrhage can be significant.
7. If there is ongoing bleeding, the patient should not be transferred to CT until the bleeding has been controlled. This might

necessitate the patient going to theatre. Discussion with the trauma team PICU consultant is advised.

8. Some cardiovascularly stable head injured children need additional vasoactive drug support to maintain their target blood pressures. If the patient only has peripheral access, then use dopamine to maintain their target systolic blood pressure. Refer to the SORT guidelines for further information on the concentration and use a large vein. If the patient has central access, then use noradrenaline to maintain target systolic blood pressure. In patients with myocardial dysfunction, central dopamine should be used in addition to noradrenaline.
9. All patients must have a urinary catheter placed.
10. Ensure blood sugar is >3mmol/l.

5. Imaging

1. CT head within 30 minutes of presentation.
2. All patients must be transferred to CT by an appropriately trained intensivist/anaesthetist with appropriate monitoring. At least: ECG, pulse oximetry, non-invasive blood pressure, end tidal carbon dioxide monitoring.
3. CT must be reported immediately for life threatening features and by a consultant radiologist within one hour.

6. Neuroprotection

1. Ensure blood sugar is >3mmol/l
2. Ensure the patient's head is in the mid-line position.
3. Ensure the bed is tilted to 30 degrees head up.
4. Ensure adequate analgesia and sedation (often require large amounts of morphine & midazolam). Muscle relaxation must be maintained during transport.
5. Maintain good oxygenation (saturations ≥98% or arterial PaO_2 >13kPa).
6. Maintain $PaCO_2$ at 4.5-5.0kPa (this can be measured on blood gases from venous, capillary or arterial sources).
7. Maintain blood pressure targets as above (section 4).
8. Maintain normothermia (core temperature 36 to 37 degrees Celsius).
9. Load with phenytoin intravenously (20mg/kg over 20 minutes).
10. Intravenous maintenance fluids should be given at 2/3 maintenance. If the patient weighs more than 10kg, use 0.9% saline as maintenance fluid. If the patient weighs less than 10kg, use 0.9% saline with 5% dextrose.
11. Keep serum sodium (Na) more than 135mmol/l. Boluses of 3ml/kg of 2.7% hypertonic saline are safe and effective.

7. Management of raised intracranial pressure

This should be undertaken if the patient shows evidence of raised intracranial pressure - bradycardia, hypertension, slowly reacting or fixed dilated pupil(s). These procedures should not be performed for evidence of cerebral oedema on CT scan.

1. Ensure all neuro-protective steps are optimized (see section 6).
2. Place the patient on a manual bagging circuit and initiate manual hyperventilation. Reduce the end tidal carbon dioxide level to correlate with a $PaCO_2$ of 4 to 4.5kPa.
3. Give a dose of either 1.25ml/kg of 20% mannitol or 5ml/kg of 2.7% sodium chloride. These therapies act to reduce cerebral oedema.
4. Discuss with the SORT PICU consultant.

Spinal immobilisation in children

The cervical spine of conscious and unconscious children with major trauma can be adequately immobilised using the following:

In line manual immobilization

or

Head blocks and tape

The use of cervical spine collars is not required initially.

Once spinal imaging has been performed, on-going management of spinal injuries should be discussed with one of the paediatric spinal surgeons.

Spinal injuries in children

Background
All children in Wessex with spinal injuries are emergently admitted to Southampton Children's Hospital paediatric intensive care unit and their care is co-ordinated by a consultant paediatric intensivist and a consultant paediatric spinal surgeon.

Southampton has 3 paediatric spinal surgeons who provide 24/7 immediate telephone advice and they are available within the hospital within 30 minutes 24/7. Therefore management plans for spinal injury patients are created within 4 hours of admission.

Complex spinal cases are operated on by a collaborative neuro-science surgical team of a consultant paediatric spinal surgeon and consultant paediatric neuro-surgeon.

Initial Management
Assessment of spinal injury is achieved using American Spinal Injury Association (ASIA) charts (see below).

Within the initial management of children with spinal injuries, neuro-protection is assured with invasive blood pressure monitoring and organ support as required (see management of brain injured child for neuro-protection strategy).

Ongoing management
Autonomic instability is actively managed whilst it remains, bladder and bowel emptying is actively managed, and skin pressure areas are actively prevented through air filled moving mattress use. The paediatric intensive care dietetic ward round reviews the nutritional requirements of spinally injured patients. The PICU nursing team are expert at reducing complications of immobility through 24 hour care. The paediatric rehabilitation team make a therapy assessment within 24 hours of admission (7 days per week) and start treatment immediately to reduce contracture complications.

When ready for discharge from PICU, ongoing care is coordinated by the paediatric spinal surgical team and the paediatric rehabilitation team.

Spinal injury assessment chart

Patient Name _____

Examiner Name _____ Date/Time of Exam _____

ASIA AMERICAN SPINAL INJURY ASSOCIATION

INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

ISCOS

MOTOR

KEY MUSCLES (scoring on reverse side)

	R	L	
C5			Elbow flexors
C6			Wrist extensors
C7			Elbow extensors
C8			Finger flexors (distal phalanx of middle finger)
T1			Finger abductors (little finger)
UPPER LIMB TOTAL (MAXIMUM)		+	= (50)

Comments:

L2		Hip flexors
L3		Knee extensors
L4		Ankle dorsiflexors
L5		Long toe extensors
S1		Ankle plantar flexors
(VAC) Voluntary anal contraction (Yes/No)		
LOWER LIMB TOTAL (MAXIMUM)	+	= (50)

SENSORY

KEY SENSORY POINTS

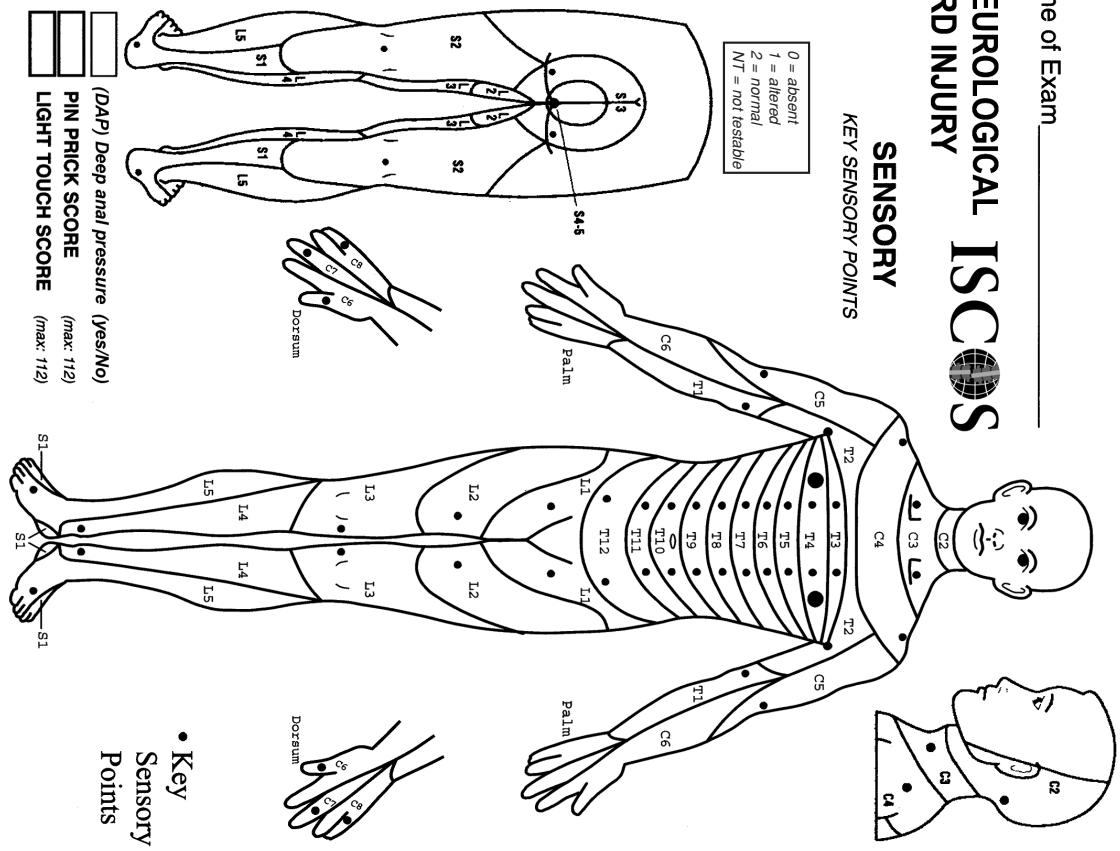
0 = absent
1 = altered
2 = normal
NT = not testable

	LIGHT TOUCH R	LIGHT TOUCH L	PIN PRICK R	PIN PRICK L
C2				
C3				
C4				
C5				
C6				
C7				
C8				
T1				
T2				
T3				
T4				
T5				
T6				
T7				
T8				
T9				
T10				
T11				
T12				
L1				
L2				
L3				
L4				
L5				
S1				
S2				
S3				
S4-5				
TOTALS (MAXIMUM)	+ (56)	+ (56)	+ (56)	+ (56)

(DAP) Deep anal pressure (yes/No)

PIN PRICK SCORE (max: 112)

LIGHT TOUCH SCORE (max: 112)



• Key Sensory Points

NEUROLOGICAL LEVEL

The most caudal segment with normal function

SENSORY R L

MOTOR

SINGLE NEUROLOGICAL LEVEL

COMPLETE OR INCOMPLETE?

Incomplete = Any sensory or motor function in S4-S5

ASIA IMPAIRMENT SCALE (AIS)

ZONE OF PARTIAL PRESERVATION

(In complete injuries only)

Most caudal level with any innervation

	R	L
SENSORY		
MOTOR		

This form may be copied freely but should not be altered without permission from the American Spinal Injury Association.

REV 04/11

Wessex children's major trauma guidelines

Spinal injury assessment guidance

Muscle Function Grading

0 = total paralysis

1 = palpable or visible contraction

2 = active movement, full range of motion (ROM) with gravity eliminated

3 = active movement, full ROM against gravity

4 = active movement, full ROM against gravity and moderate resistance in a muscle specific position.

5 = (normal) active movement, full ROM against gravity and full resistance in a muscle specific position expected from an otherwise unimpaired peson.

5* = (normal) active movement, full ROM against gravity and sufficient resistance to be considered normal if identified inhibiting factors (i.e. pain, disuse) were not present.

NT = not testable (i.e. due to immobilization, severe pain such that the patient cannot be graded, amputation of limb, or contracture of >50% of the range of motion).

ASIA Impairment (AIS) Scale

☐ **A = Complete.** No sensory or motor function is preserved in the sacral segments S4-S5.

☐ **B = Sensory Incomplete.** Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-S5 (light touch, pin prick at S4-S5: or deep anal pressure (DAP)), AND no motor function is preserved more than three levels below the motor level on either side of the body.

☐ **C = Motor Incomplete.** Motor function is preserved below the neurological level**, and more than half of key muscle functions below the single neurological level of injury (NLI) have a muscle grade less than 3 (Grades 0-2).

☐ **D = Motor Incomplete.** Motor function is preserved below the neurological level**, and at least half (half or more) of key muscle functions below the NLI have a muscle grade ≥ 3.

☐ **E = Normal.** If sensation and motor function as tested with the ISNCSCI are graded as normal in all segments, and the patient had prior deficits, then the AIS grade is E. Someone without an initial SCI does not receive an AIS grade.

**For an individual to receive a grade of C or D, i.e. motor incomplete status, they must have either (1) voluntary anal sphincter contraction or (2) sacral sensory sparing with sparing of motor function more than three levels below the motor level for that side of the body. The Standards at this time allows even non-key muscle function more than 3 levels below the motor level to be used in determining motor incomplete status (AIS B versus C).

NOTE: When assessing the extent of motor sparing below the level for distinguishing between AIS B and C, the ***motor level*** on each side is used; whereas to differentiate between AIS C and D (based on proportion of key muscle functions with strength grade 3 or greater) the ***single neurological level*** is used.

Steps in Classification

The following order is recommended in determining the classification of individuals with SCI.

1. Determine sensory levels for right and left sides.
2. Determine motor levels for right and left sides.
   Note: in regions where there is no myotome to test, the motor level is presumed to be the same as the sensory level, if testable motor function above that level is also normal.
3. Determine the single neurological level.
   This is the lowest segment where motor and sensory function is normal on both sides, and is the most cephalad of the sensory and motor levels determined in steps 1 and 2.
4. Determine whether the injury is Complete or Incomplete. (i.e. absence or presence of sacral sparing)
   If voluntary anal contraction = **No** *AND all S4-5 sensory scores =* **0** *AND deep anal pressure =* **No,** *then injury is COMPLETE. Otherwise, injury is incomplete.*
5. Determine ASIA Impairment Scale (AIS) Grade:

Is injury Complete?

NO ↓

Is injury motor Incomplete?

YES ↓

If **YES,** AIS=A and can record ZPP (lowest dermatome or myotome on each side with some preservation)

If **NO**, AIS=B (Yes=voluntary anal contraction OR motor function more than three levels below the motor level on a given side, if the patient has sensory incomplete classification)

Are at least half of the key muscles below the single neurological level graded 3 or better?

NO ↓ AIS=C

YES ↓ AIS=D

If sensation and motor function is normal in all segments, AIS=E
Note: AIS E is used in follow-up testing when an individual with a documented SCI has recovered normal function. If at initial testing no deficits are found, the individual is neurologically intact; the ASIA Impairment Scale does not apply.

Managing eyes in injured children

Injured eyes
If there is thought to be ocular/globe trauma:

1) Contact the ophthalmology second on call through switchboard. They will review the patient and provide on-going management plans.
2) In conscious children, cover the injured eye with an eye shield.

Non-injured eye care in unconscious patients
If the child's eyes are not injured, but are not fully closing whilst unconscious:

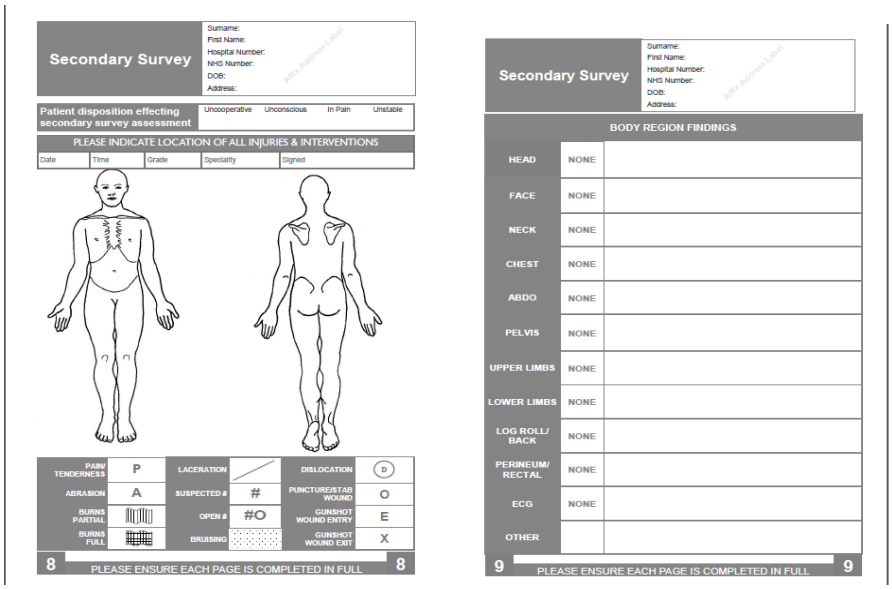
1) Use a lubricating eye ointment 2-3 hourly to avoid exposure.

EXPOSURE, MISSED INJURY SURVEYS and ENVIRONMENTAL CONTROL

Primary, Secondary and Tertiary surveys

Regular examination of trauma patients is vital to identify all of their injuries. The role of the **primary survey** is allocated to one team member and performed as soon as the handover from the pre-hospital team is complete. It identifies life threatening injuries and allows simultaneous resuscitation. If there is any deterioration of the patient then the primary survey should be repeated.

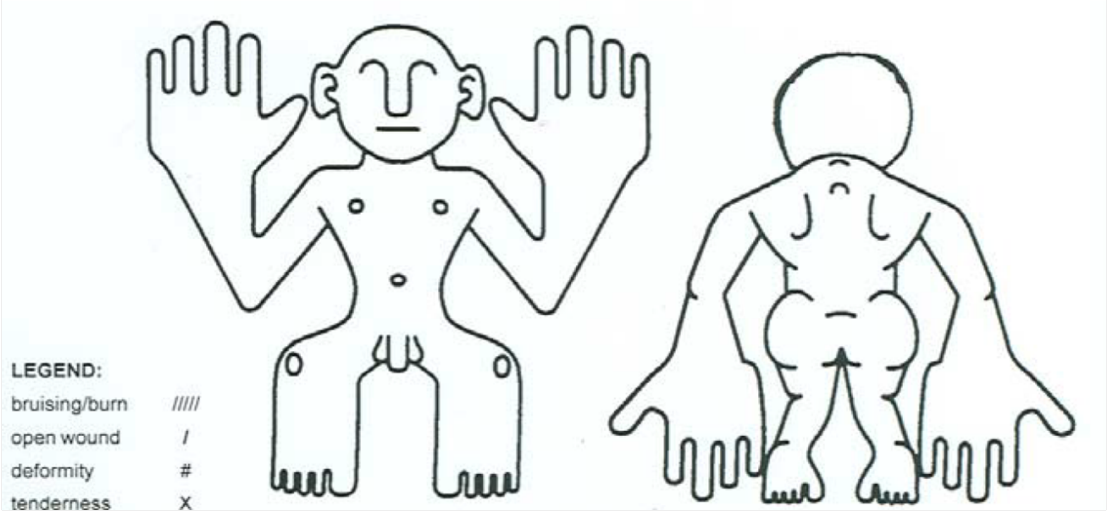
The **secondary survey** is a head to toe examination of the patient, carried out immediately after resuscitation from life threatening injuries has been completed. It is to identify any other injuries that have been missed by the primary survey. It includes a detailed history of the event and examination of each body region. It should be performed in the Emergency department prior to any patient being transferred to a ward or high dependency area to allow appropriate imaging and initial management of the injury to occur. The ED team leader should allocate this role to the most appropriate member of the trauma team, for example surgical, orthopaedic or emergency department registrar. This examination should be documented in the Trauma booklet and if there are any outstanding reviews required for completion, then the name and contact details must be provided for the clinician responsible.



A **tertiary survey** is another head to toe examination of the patient at a later time, ideally when the patient has had distracting injuries managed and is fully able to comment on the examination. It is a repeat of the secondary survey to look for any other injuries missed on the initial examinations. This should be completed by the admitting specialty for the patient on the post take ward round. For the majority of patients this will be the next working day and within 24hrs of admission. If the patient is sedated on the PICU then it must be clearly documented that the tertiary survey is outstanding and needs to be performed once the patient conscious.

Suggested format for Tertiary survey documentation

Region	Action	Normal	Abnormality
a) Head.	inspect and palpate scalp		
	inspect and palpate face		
	Cranial Nerve assessment		
	Eyes (PEARL/FROM & no double vision/Nystagmus)		
	Mouth and teeth		
	Ears (including external auditory canal & tympanic membranes)		
b) Neck/throat	inspect/palpate		
c) Chest -	inspect/palpate/auscultate {anterior and posterior}		
d) Abdomen	inspect/palpate/auscultate {anterior and flanks}		
	external genitalia/perineum		
e) Back	inspect and palpate		
f) Extremities LOOK, FEEL, MOVE inspect bones, palpate bones/pulses, test sensation, move all joints assessing TPR	C spine, T spine, L spine, Sacrum, Coccyx		
	Clavicles, ACJ, SHJ, Humerus, EJ, radius, ulna, Wrist, carpal bones, thumb and digits		
	Pelvis, Hip J, femur, knee, tibia, fibula, ankle, tarsal bones, toes		



Present at tertiary survey: mother/father/relative

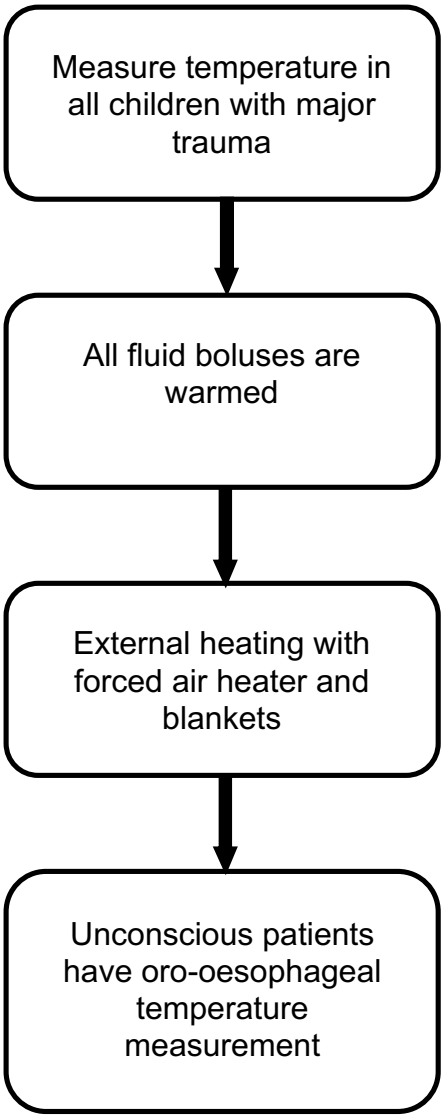
Tetanus status: up to date/needs booster

Radiology Review	Date	Normal/Not indicated	Abnormality
CXR			
Pelvic X ray			
C spine X ray			
T/L/S spine X ray			
Extremities (?what)			
CT head			
CT neck			
CT abdo/pelvis			
Other X ray(?what)			
Blood tests			

Summary list of injuries	Management plan + lead Consultant
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

Doctor performing tertiary survey: Grade:

Ensuring children stay warm after trauma



Paediatric hypothermia guideline

This guideline has been developed for use for children presenting to Southampton Children's Hospital Major Trauma Centre with ACCIDENTAL HYPOTHERMIA defined as a history of cold exposure (elemental, immersion, submersion) and core temperature <35^{o}C.

DIAGNOSIS

- Axillary and oropharyngeal thermometers do not correlate with core body temperature and should not be relied on for accurate monitoring.
- Rectal temperature probes can provide an initial reading, but may be erroneous if placed in stool.
- Oesophageal thermistor probe placed in the lower 1/3 rd of the oesophagus should be obtained in all intubated patients. Chest x-ray to confirm placement (tip should lie at level of T8/9)

MANAGEMENT

- The vast majority of patients will require only supportive/minimally invasive management, passive warming with blankets +/- under & over external forced air heating (such as bair hugger).
- Warmed fluids will not increase core body temperature but will reduce further heat loss. Therefore only use for clinical haemodynamic effect.
- Bradycardia and most arrhythmias will improve with rewarming. Only treat if associated with significant haemodynamic compromise.
- Careful consideration of patient movement to minimise risk of precipitating cardiac instability.
- Consider Extra-corporeal Membrane Oxygenation (ECMO) for those in cardiac arrest or those with cardiac instability unresponsive to medical management (see below).

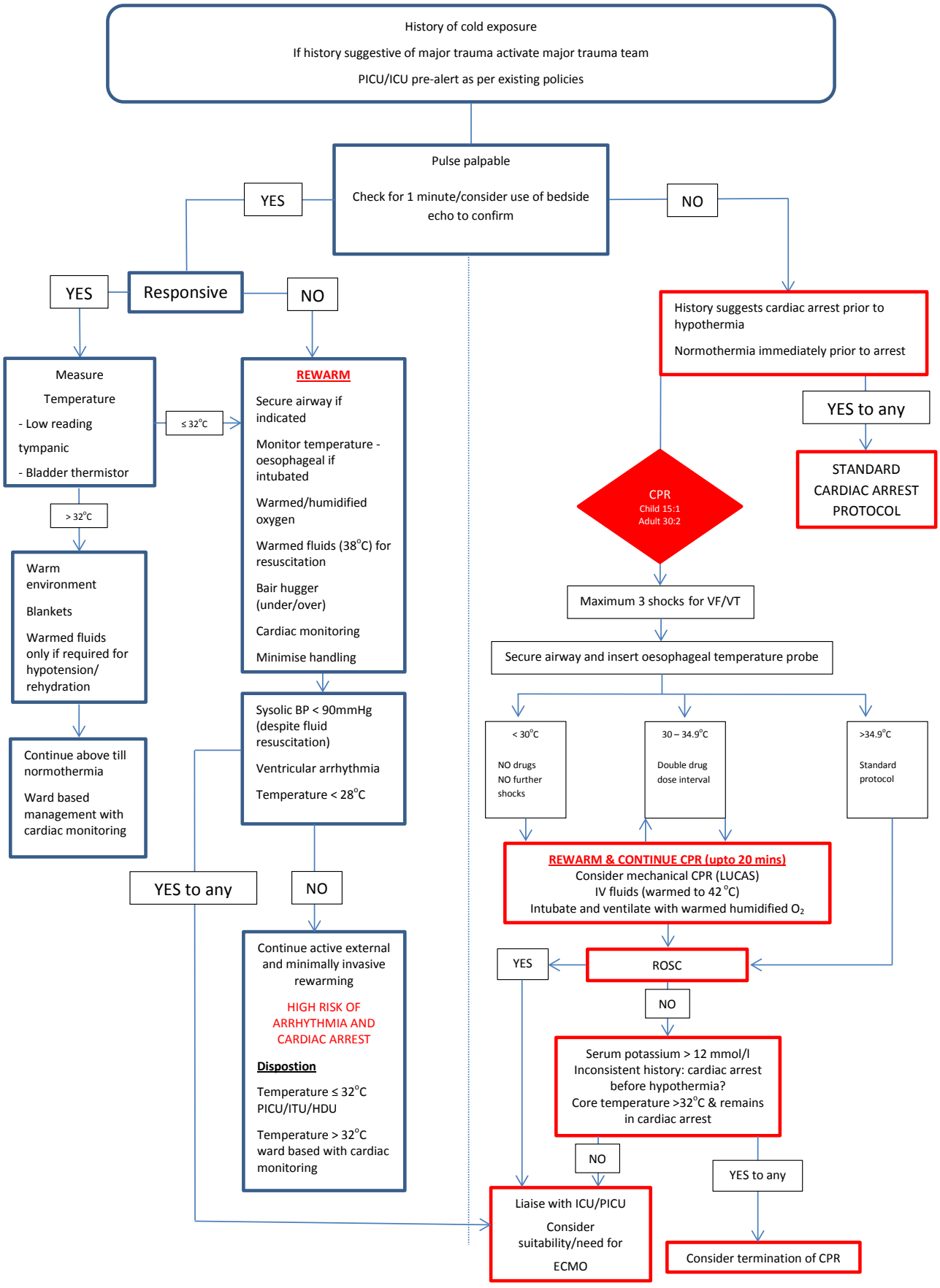
DISPOSITION

- Any patient with a reduced level of consciousness should be assessed by the paediatric intensive care team for admission to the paediatric intensive care unit.
- Patients with cardiac instability or core body temperature < 28^{o}C should be admitted to the paediatric intensive care unit.

EXTRA-CORPOREAL MEMBRANE OXYGENATION (ECMO)

- For consideration of ECMO in a child, the on call consultant paediatric intensive care consultant must be involved and will co-ordinate the ECMO team using the ECMO escalation policy.

Management of hypothermia in children



Paediatric (age <16) Major Trauma Initial Prophylactic Antibiotic Dose

(to be given within 3 hours from injury)

Penetrating eye injury
Convexity skull # with brain penetration

YES → **Cefotaxime 50mg/kg iv**
(Chloramphenicol 25mg/kg if severe penicillin allergy)

If ENT/GU/GI injury or contaminated wound, add metronidazole 7.5mg/kg IV

NO ↓

ENT / Maxfax
Genitourinary
Penetrating abdo trauma
Ruptured viscus

→ **Cefuroxime 30mg/kg IV**
+ Metronidazole 7.5mg/kg IV*

↓

Chest penetration
Emergency thoracostomy

→ **Cefuroxime 30mg/kg IV***
(max 1.5g)
If contaminated wound, add metronidazole 7.5mg/kg IV

↓

Open limb fracture

→ **Co-amoxiclav 30mg/kg IV* (max 1.2g)**

↓

Scalp laceration
Open soft tissue

→ **Contaminated wound?**

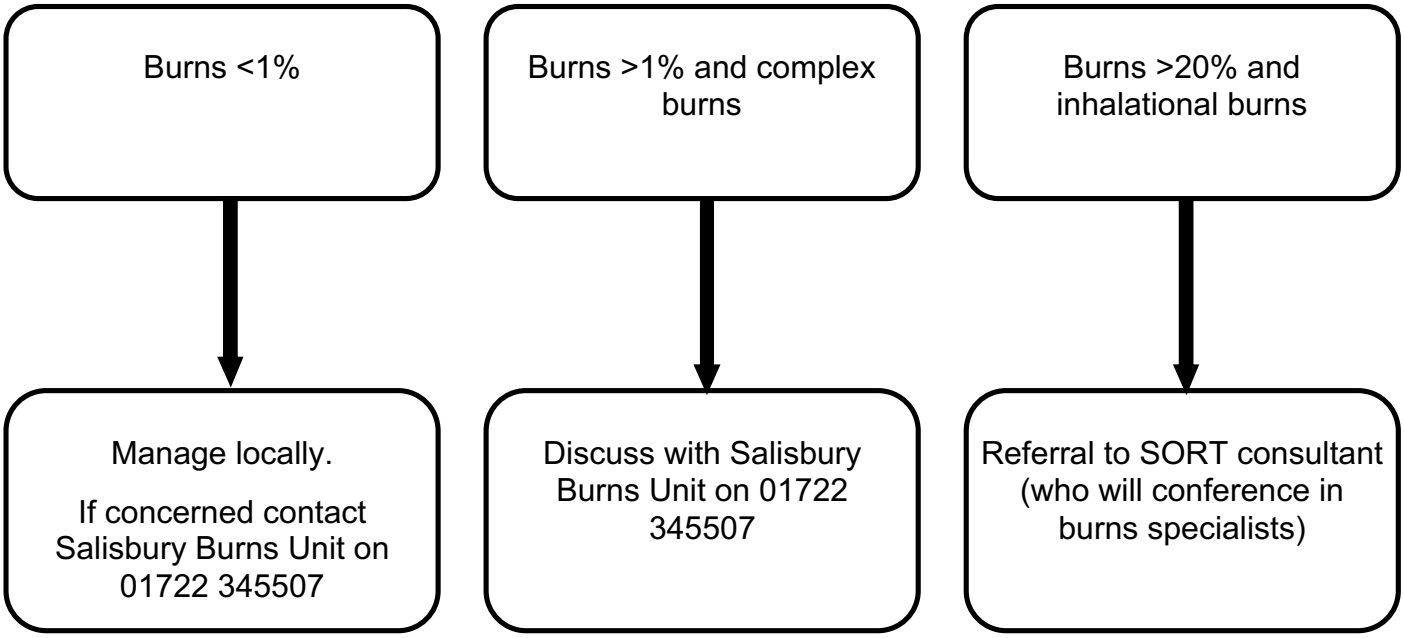
↓

No prophylactic antibiotics required

*If severe penicillin allergy: clindamycin 10mg/kg (max 600mg) + gentamicin 3mg/kg
If antibiotics given prior to fluid resuscitation / blood products, repeat all doses if >60ml/kg administered.
Repeat antibiotic doses if major blood loss (>25ml/kg) during surgery.
Assess tetanus status
Give PREVENAR 13 in BOS# if not received as child
For subsequent antibiotic regimen following initial dose, please see full antibiotic prophylaxis guidelines

BURN INJURIES

Burns decision flow chart for children



Complex burns

- **Site:** Face, hands, perineum, feet, circumferential
- **Depth:** Full thickness any site
- **Mechanism:** Chemical, Radiation, High pressure, Electrical
- **Age:** <5 years
- **Toxic shock:** Delayed onset of High temp, rash, D&V, systemically unwell

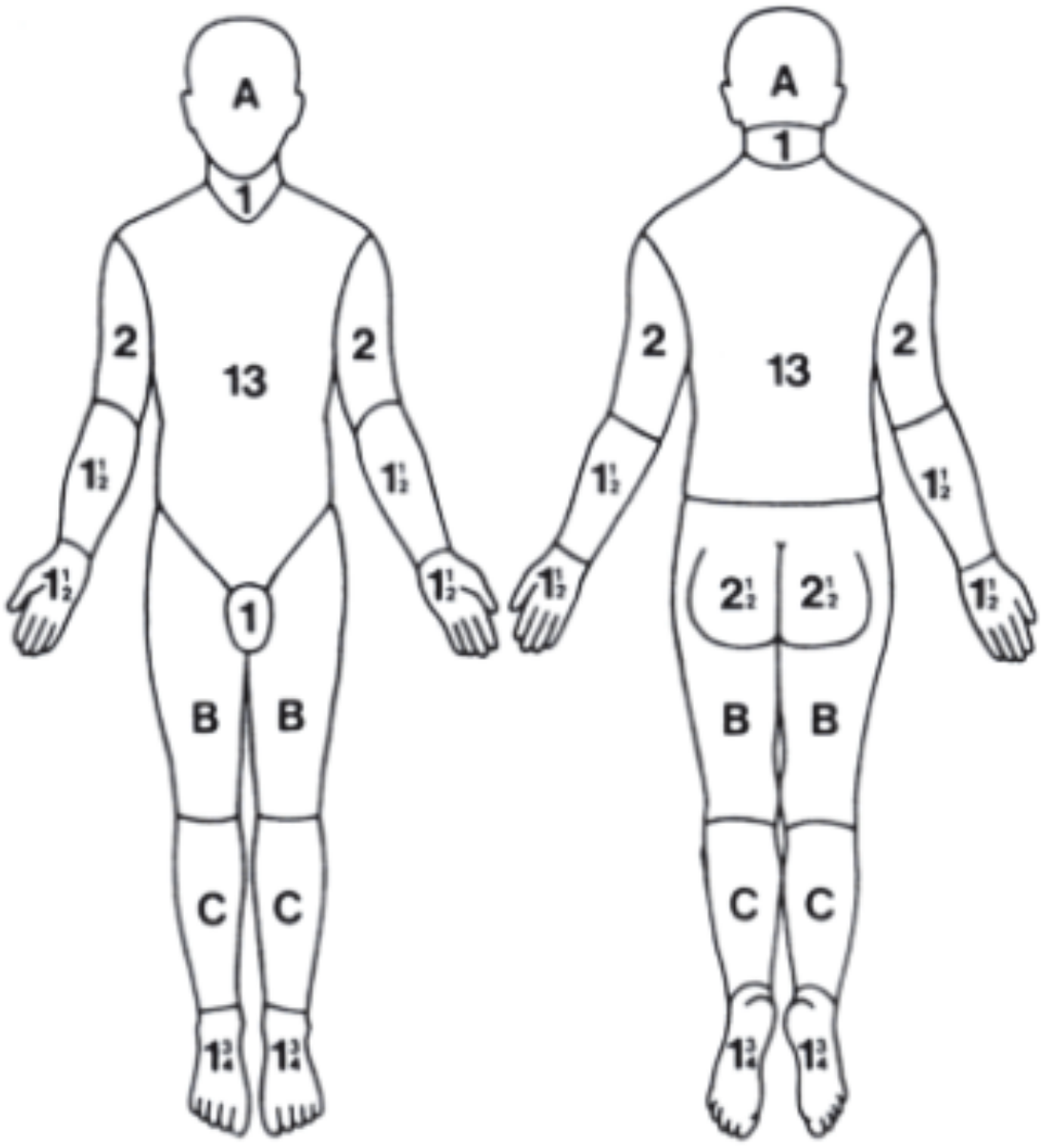
Burns dressings

Non chemical burns – use cling film to dress the burn

Chemical burns – discuss dressing with Salisbury burns unit

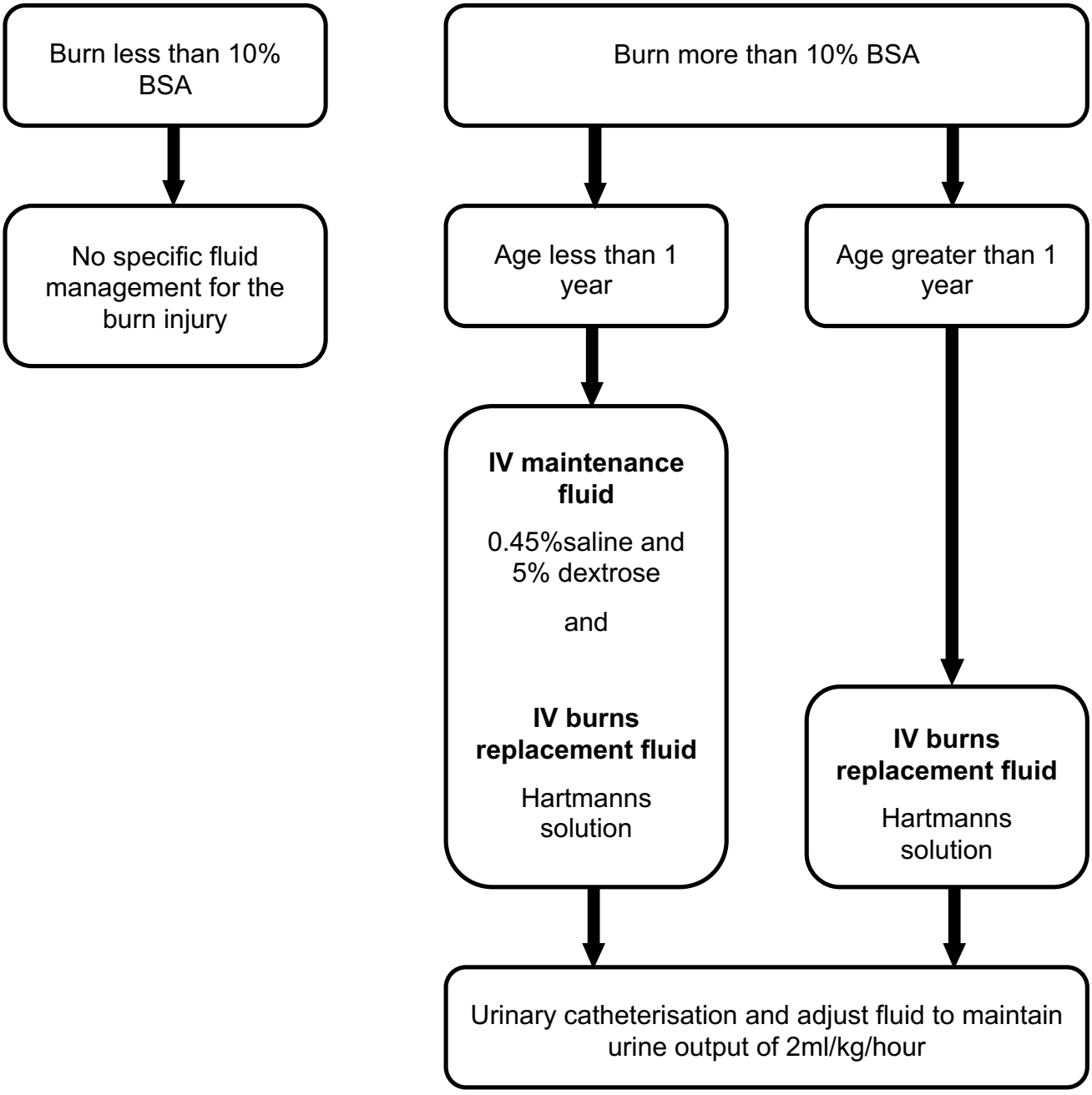
Calculation of percentage body surface area burnt

Percentage body surface area chart



	% Surface area at age				
Area	**0 years**	**1 year**	**5 years**	**10 years**	**15 years**
A	9.5	8.5	6.5	5.5	4.5
B	2.75	3.25	4	4.5	4.5
C	2.5	2.5	2.75	3	3.25

Initial fluid management in children with burns



Maintenance fluid and burns replacement fluid calculation

Maintenance fluid = 80ml/kg/day (children less than 1 year old)

Burns replacement fluid per day = 2 x % body surface area burn x weight (kg)

Half of the daily burns replacement fluid is given over the first 8 hours from the time of the burn.

The next half of the burns replacement fluid is given over the next 16 hours.

ORTHOPAEDIC and VASCULAR INJURIES including plastic surgery

Emergency department management femoral fractures in children with major trauma

Assess neuro-vascular status of limb

1) Check for palpable dorsalis pedis and posterior tibial pulse in the affected limb

2) If the patient is conscious, assess sensation in affected lower leg and foot.

↓

Provide adequate analgesia
PO/nasal/IV analgesia
+/- femoral nerve or fascia iliaca block

↓

Child under 3 months of age

Support limb in a double layer wool and crepe bandage. Monitor neurovascular status.

Child over 3 months of age

Manipulation of fracture and application of adhesive skin traction. Monitor neurovascular status.
See application of skin traction for femoral fractures in children with major trauma.

↓

Further management of fractured femur organised by orthopaedic team

1) Children under 3 months of age will be placed in a Pavlik harness

2) Children under 16kg and over 3 months will be placed in Gallows traction

3) Children over 16kg will be placed in a Thomas splint

↓

Application of skin traction for femoral fractures in children with major trauma

ACTION	RATIONALE
1. Ask family if child has any known allergies to tape	
2. Measure adhesive extension set (either child or adult size) and cut to required length (extends to top of leg). Cut ends to round off.	Correct length to fit child's leg. Rounded corners helps to prevent edges peeling down
3. Perform a neurovascular assessment of the affected limb (Tucker 1998, Wright 2007)	To record baseline observation and ensure normal circulation, sensation and movement
4. Manual traction applied by hands gripping and holding at the ankle, keeping leg in alignment. Maintain check on dorsalis pedis pulse. 	To straighten limb and reduce fracture. To aid with application of traction tapes. Check neurovascular status of limb and ensure foot pulse is not lost when fracture is reduced.
5. Traction tapes placed to medial and lateral aspects of the limb with foam padding protecting the malleoli. 	Protects bony prominences against incidence of pressure sores.
Check there are no creases in skin extension tape. Cut 'V' shaped nicks in the extension tape over knee area to improve conformity.	Prevention of potential blister formation
Leave enough room at the sole of the foot to allow for plantar flexion of the foot	Facilitates normal ankle movement, preventing potential foot drop.

6. Secure traction tapes with crepe bandages in figure-of-eight style (Love 2000), starting just above malleoli, up to upper thigh. Leave knee area exposed.  The bandages should avoid the malleoli, Achilles' tendon and peroneal nerve (Draper & Scott 1996)	Keeps traction tapes in place N.B. tight bandaging over fibula head at the knee can cause peroneal nerve compression = foot drop. Leaving knee exposed also allows for checking of leg alignment. Avoid pressure over at risk areas. Pressure over peroneal nerve, which runs around the proximal fibula, has potential to cause foot drop (Love 2000)
7. Tie traction cords to end of trolley/ bed	To maintain traction pull and for child's comfort
N.B. This is a temporary measure until the child is stabilized. Further management is led by the paediatric orthopaedic team and will involve either a Thomas splint or Gallows traction being applied.	

Management of pelvic and acetabular fractures in children

Background and justification
As paediatric pelvic fractures are a rare event then most guidance is from adult evidence. Therefore, paediatric pelvic fracture management in Southampton accords to the British Orthopaedic Association Standards for Trauma (BOAST) number 3 with paediatric specific adjustments to standards 3, 9, 10, 11, 12 and 13.

Pelvic Ring Fractures and Dislocations:
1. Major pelvic (and acetabular) fractures and dislocations may be associated with major haemorrhage. The early application of a pelvic binder or crossed sheet will aid resuscitation and facilitate laparotomy if required.

2. In the presence of continuing haemorrhage, the urgent treatment must include early Octaplas, platelets and packed red cells as per the paediatric massive haemorrhage protocol. If there remains ongoing haemodynamic instability, attributable to the pelvic injury, then the further treatment options are open pelvic packing and embolisation. Alert the on call interventional radiology consultant available through switchboard.

3. The choice of imaging to define the pelvic injury is a joint decision making process involving the consultant orthopaedic surgeon and on call consultant radiologist. CT shall not be performed routinely. This is due to risk of cancer secondary to radiation utilised in scan. Plain X-ray and MRI should be considered.

4. A high index of suspicion of genito-urinary damage requires early contrast studies (cystography + CT and urethrography). Intraperitoneal bladder tears, bladder neck involvement or penetrating bone fragments require open bladder repair; extraperitoneal injuries can be managed by urethral drainage. These all demand urgent urological input.

5. Open pelvic fractures, with wounds to the groin, buttock, perineum, vagina or rectum, require urgent bladder drainage by cystostomy tube and bowel diversion with an end-colostomy (with washout). These demand urgent consultant paediatric surgical and consultant paediatric urology input. Both of these consultants are available through switchboard at UHS. Any colostomy should be sited in an upper abdominal quadrant remote from potential definitive pelvic surgical fixation approaches.

6. Posterior urethral injuries identified by urethrography should be managed initially by open or ultrasound-guided suprapubic catheterisation. Subsequently, when necessary, definitive repair by delayed urethroplasty will be part of specialist care. This is carried out by the on call consultant paediatric urology surgeon.

7. Following haemodynamic and temporary skeletal stabilisation, a definitive plan for pelvic reconstruction needs to be formulated and carried out by a specialist pelvic surgeon as soon as possible and ideally within five days.

8. Southampton has 6 paediatric orthopaedic consultants and all the supporting specialties to manage multi-system injuries.

9. Patient follow-up should occur in the specialist pelvic units to ensure full advice is available for the pain, physical, urological and sexual disabilities which are common outcomes.
In some incidences of complex trauma the adult specialist pelvic surgeons will be involved with the paediatric orthopaedic surgeons for non-emergent fixation. This meets national criteria for a specialist unit.

Acetabular Fractures:
10. Hip dislocations must be reduced urgently and then an assessment of stability recorded. The neurovascular status before and after reduction must be documented. Skeletal traction should be applied.
In some younger children skin traction or spica casting may be considered as an alternative to skeletal traction.

11. Following reduction of hip dislocations, the choice of imaging to further define the pelvic injury is a joint decision making process involving the consultant paediatric orthopaedic surgeon and on call consultant paediatric radiologist. CT shall not be performed routinely. This is due to risk of cancer secondary to radiation utilised in scan. Plain X-ray and MRI should be considered.

12. Acetabular reconstruction will be performed by a paediatric orthopaedic specialist with or without input from the adult pelvic team as early as possible, ideally within five days but no later than 10 days from injury.

13. Routine chemothomboprophylaxis is not indicated in children under 16 years of age unless the child has multiple injuries and organ support requirements. Decision to be made on a case by case basis.

Management of open fractures in children

Paediatric open fracture management accords to the British Orthopaedic Association Standards for Trauma (BOAST) number 4 with paediatric specific adjustments to standards 1 and 2 in view of smaller patient size.

1. Intravenous antibiotics should be co-amoxiclav 30mg/kg (max dose 1.2g) or for penicillin allergic patients - clindamycin 10mg/kg (maximum dose 600mg). Consideration of addition of gentamicin 3mg/kg (maximum dose 160mg) should be considered in gross contamination. Continuation should be IV co-amoxiclav then conversion to oral as needed on a case by case basis. Continuation in penicillin allergic patient should be discussed with the paediatric infectious disease team.

2. The vascular and neurological status of the limb is assessed systematically and repeated at intervals, particularly after reduction of fractures or the application of splints. Neurological assessment in a distressed child can be challenging and should be done at an appropriate level, any finding should be clearly documented. It should be repeated by the surgeon performing initial or subsequent surgeries.

3. Vascular impairment requires immediate surgery and restoration of the circulation using shunts, ideally within 3-4 hours, with a maximum acceptable delay of 6 hours of warm ischaemia.

4. Compartment syndrome also requires immediate surgery, with 4 compartment decompression via 2 incisions – see guidance below.

5. Urgent surgery is also needed in some multiply injured patients with open fractures or if the wound is heavily contaminated by marine, agricultural or sewage matter.

6. A combined plan for the management of both the soft tissues and bone is formulated by the paediatric orthopaedic surgical team in liaison with plastic surgeons and clearly documented.

7. The wound is handled only to remove gross contamination and to allow photography, then covered in saline soaked gauze and an impermeable film to prevent desiccation

8. The limb, including the knee and ankle, is splinted

9. Combined plastics and paediatric orthopaedic management occurs in Southampton. The plastic surgeons can be contacted directly via the hospital switchboard on their mobile telephones in working hours from Monday to Wednesday. Out of these hours, all cases should be discussed with the on-call plastic surgical consultant at Salisbury Hospital.

10. The primary surgical treatment (wound excision and fracture stabilisation) of severe open tibial fractures is provided within Southampton.

11. The wound, soft tissue and bone excision (debridement) is performed by consultant plastic and paediatric orthopaedic surgeons working together on scheduled trauma operating lists within normal working hours and within 24 hours of the injury unless there is marine, agricultural or sewage contamination. The 6 hour rule does not apply for solitary open fractures. Antibiotic prophylaxis is mentioned in section 1 and should be administered at wound excision and continued for 72 hours or definitive wound closure, whichever is sooner

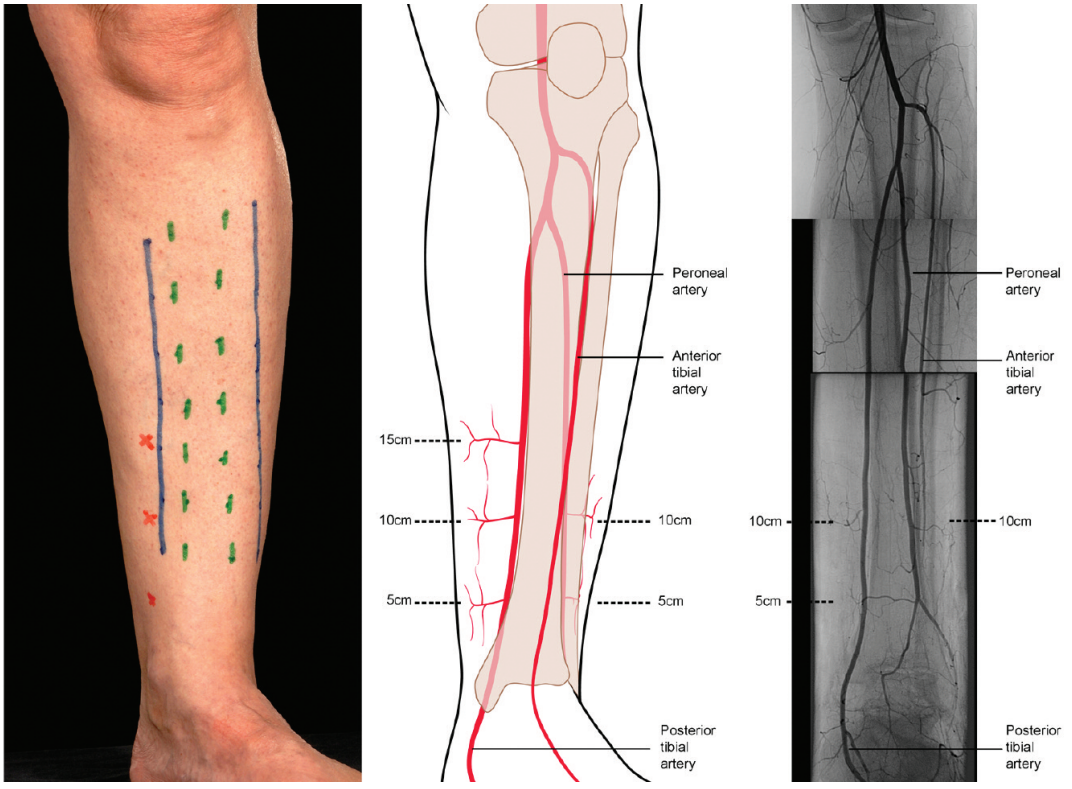
12. If definitive skeletal and soft tissue reconstruction is not to be undertaken in a single stage, then vacuum foam dressing or an antibiotic bead pouch is applied until definitive surgery.

13. Definitive skeletal stabilisation and wound cover are achieved within 72 hours and should not exceed 7 days.

14. Vacuum foam dressings are not used for definitive wound management in open fractures.

15. The wound in open tibial fractures in children is treated in the same way as adults

Recommended incisions for fasciotomy and wound extensions



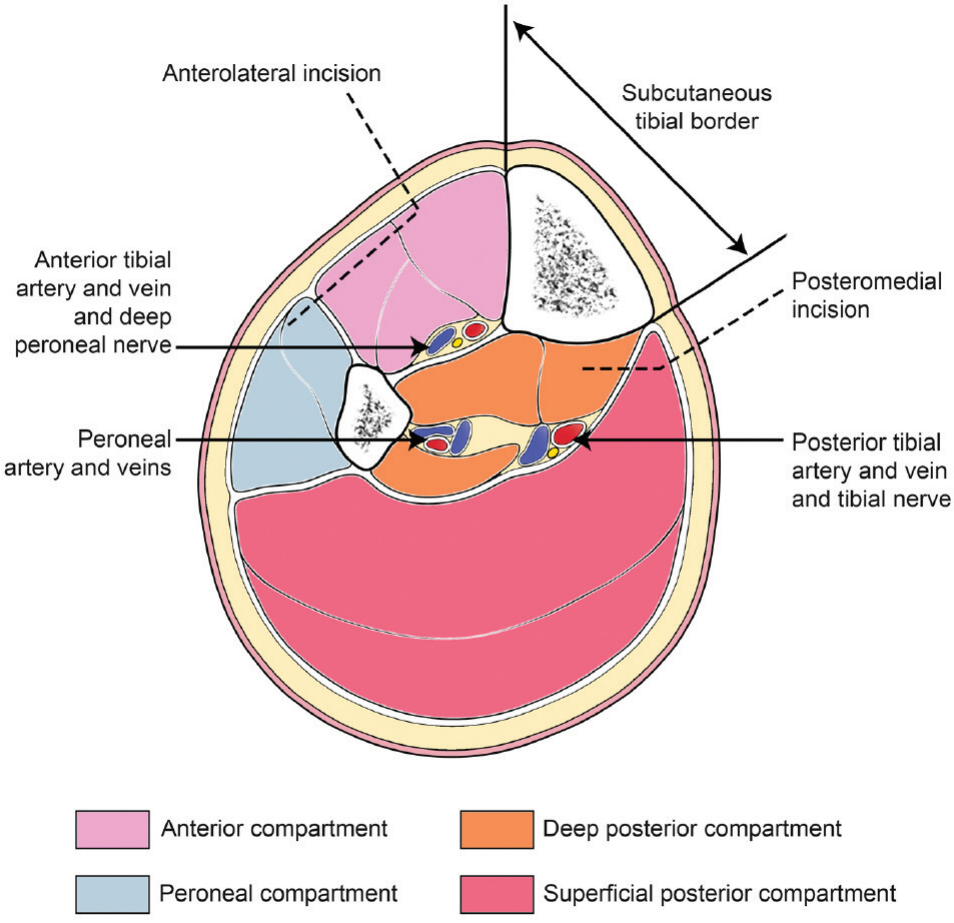
(a) (b) (c)

(a) Margins of subcutaneous border of tibia marked in green, fasciotomy incisions in blue and the perforators on the medial side arising from the posterior tibial vessels in red.

(b) line drawing depicting the location of the perforators.

(c) montage of an arteriogram. The 10cm perforator on the medial side is usually the largest and most reliable for distally-based fasciocutaneous flaps. In this patient, the anterior tibial artery had been disrupted following an open dislocation of the ankle; hence the poor flow evident in this vessel in the distal 1/3 of the leg. The distances of the perforators from the tip of the medial malleolus are approximate and vary between patients. It is essential to preserve the perforators and avoid incisions crossing the line between them.

Cross-section through the leg showing incisions to decompress all four compartments



Management of supracondylar fractures including guidance for peripheral nerve and vessel injury for all limbs.

Background
Supracondylar fractures of the distal humerus are the most common fractures about the elbow seen in children. They may be difficult to manage and can be associated with significant complications including nerve injury, vascular compromise, malunion and compartment syndrome.
Management follows the principles of British Orthopaedic Association Standards for Trauma (BOAST) number 11.

1. A documented assessment of the limb, performed on presentation, must include the status of radial pulse, digital capillary refill time and the individual function of the radial, median (including anterior interosseous) and ulnar nerves.

2. These injuries require early surgical treatment, ideally on the day of admission. However, night-time operating is not necessary unless there are indications for urgent surgery.

3. Indications for urgent surgical treatment include absent radial pulse, clinical signs of impaired perfusion of the hand and digits, and evidence of threatened skin viability.

4. Surgical stabilisation should be with bicortical wire fixation. Crossed wires are associated with a lower risk of loss of fracture reduction, whereas divergent lateral wires reduce the risk of injury to the ulnar nerve.

5. If a medial wire is used, techniques to avoid ulnar nerve injury should be employed and recorded on the operation note.

6. 2mm diameter wires should be used, where possible, to achieve stability.

7. Cubitus varus should be avoided by achieving a carrying angle (or Baumann angle) similar to the contralateral arm.

8. The majority of nerve injuries associated with supracondylar fractures or its surgical management are transient neuropraxias and can be managed expectantly. If there is concern over iatrogenic injury then a thorough assessment by a consultant paediatric orthopaedic surgeon is required for consideration of nerve exploration.

9. The majority of vascular impairments associated with supracondylar fractures resolve with fracture reduction. A perfused limb does not require brachial artery exploration whether or not the radial pulse is present.

10. In case of children presenting with an ischaemic limb, the case should be discussed with the on-call generic consultant vascular surgeon in Southampton prior to operative reduction.

11. If the limb remains ischaemic after open or closed fracture reduction then exploration of the brachial artery is required with a surgeon competent to perform a small vessel vascular repair.

12. Documented post-operative monitoring of neurovascular status should occur until the treating surgeon is confident there is no risk of vascular compromise or compartment syndrome.

13. Suspicion of compartment syndrome or deterioration of perfusion should prompt immediate vascular re-assessment and intervention if required.

14. Post-operative radiographs should be obtained between 4 and 10 days to ensure maintenance of reduction.

15. Wire removal and mobilisation is typically recommended at 3 to 4 weeks.

16. Routine long-term follow up is not usually required.

ANALGESIA

General principles

Use regular simple analgesics first line and this will reduce the amount of opiates required, as well as limit their side effects.

- Paracetamol; optimise dose according to the latest cBNF.
- Ibuprofen; if there are no contraindications to the use of NSAIDs, or consider a short course of diclofenac.
- Opioids; this will depend on the co-morbidities of the patient and route of administration available. This may range from oral morphine as required to intravenous morphine infusions and patient controlled analgesia pumps.
- The paediatric pain team can provide further advice and guidance in hours. Out of hours then contact the paediatric anaesthetic registrar on-call.

Paediatric analgesia in specific traumatic conditions

Analgesia for traumatic amputation
Children with traumatic amputation will receive analgesia in the acute phase including ketamine and opioids (morphine and fentanyl). Children with injuries involving amputation are always anaesthetized for their acute management.

Prior to amputation of limbs, consideration of the addition of regional anaesthesia or epidural anaesthesia should be made.

All children needing or having undergone amputation should be reviewed by the paediatric pain team.

Post-operatively, under the direction of the paediatric pain team, additional specific analgesia to reduce phantom limb pain will be commenced.

Analgesia for multiple rib fractures
Multiple rib fractures are very painful and in a conscious child can lead to shallow breathing, respiratory secretion poling, segmental lung collapse and hypoxaemia.
Adequate analgesia with intravenous opioid agents can add to respiratory compromise. Therefore, placement of a thoracic epidural for these children is recommended.

Epidural placement is organised through the paediatric pain team and is achieved under general anaesthesia in theatre.

TRAUMA IMAGING

Principles of imaging in paediatric trauma

General principles:
Adult trauma imaging guidelines are not appropriate for the entire paediatric age group. Specific paediatric trauma imaging guidelines have been published by the Royal College of radiologists in 2014. These guidelines promote a measured approach to imaging children with a child-specific approach being required for each individual case.

In major trauma, a child can suffer an isolated injury which may mean that there is no clinical need to image the whole body.

Head imaging
Computed tomography (CT) of the head as per NICE guidance

Spinal radiography
No evidence to suggest cervical spine CT is indicated unless severe multisystem trauma.
Plain radiographs are sufficient to exclude bony injury in the majority of cases.
Discussion is required with the on call consultant paediatric radiologist regarding cross sectional imaging of the cervical, thoracic or lumbar spine.
Magnetic resonance imaging should be used if clinical concern or abnormal neurology

Chest imaging
Thoracic trauma is rare in the paediatric age group.
Thoracic CT is not indicated unless the chest radiograph shows a significant injury. Discussion is required with the on call consultant paediatric radiologist regarding CT imaging of the chest.

Abdomen imaging
CT of the abdomen is only indicated in severe multi system trauma or clinical concern based on clinical examination.
Discussion is required with the on call consultant paediatric radiologist regarding CT imaging of the abdomen. Consideration of the use of ultrasound will be made.

Concerning clinical abdominal features in trauma:
Lap belt injury
Abdominal wall eccymoses
Abdominal Tenderness in a conscious patient
Abdominal distension
Clinical evidence of persistent hypovolaemia
Blood from the rectum or NG tube

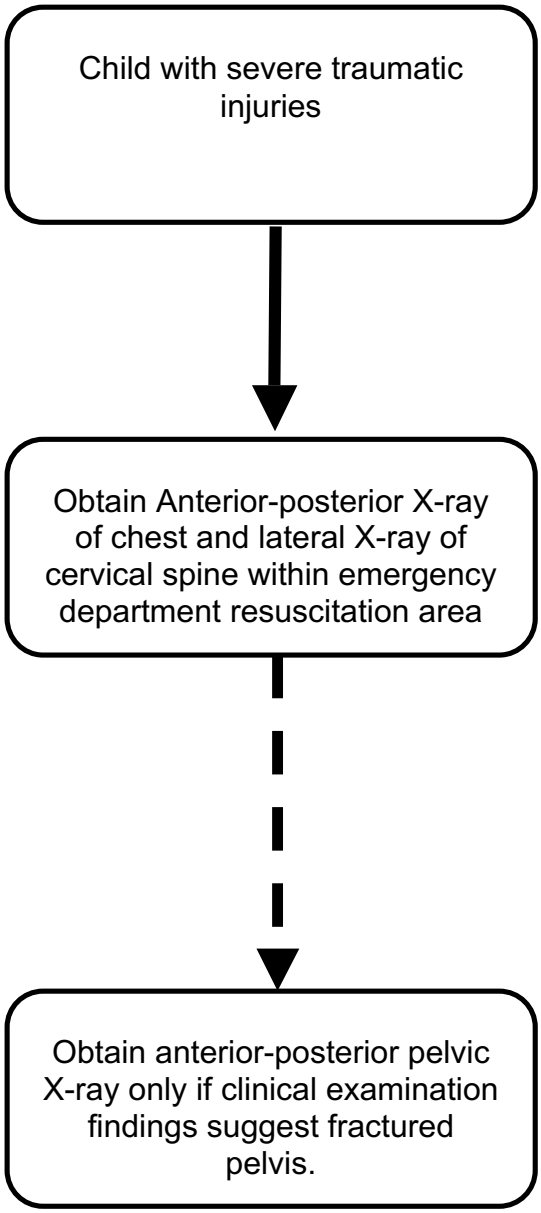
Pelvic imaging
Plain radiography is indicated with clinical suspicion of pelvic fracture. A pelvic x ray is not indicated in the primary assessment of the severely injured child.

CT of the pelvis is only indicated in severe multi system trauma or clinical concern based on clinical examination. Discussion is required with the on call consultant paediatric radiologist regarding CT imaging of the pelvis.

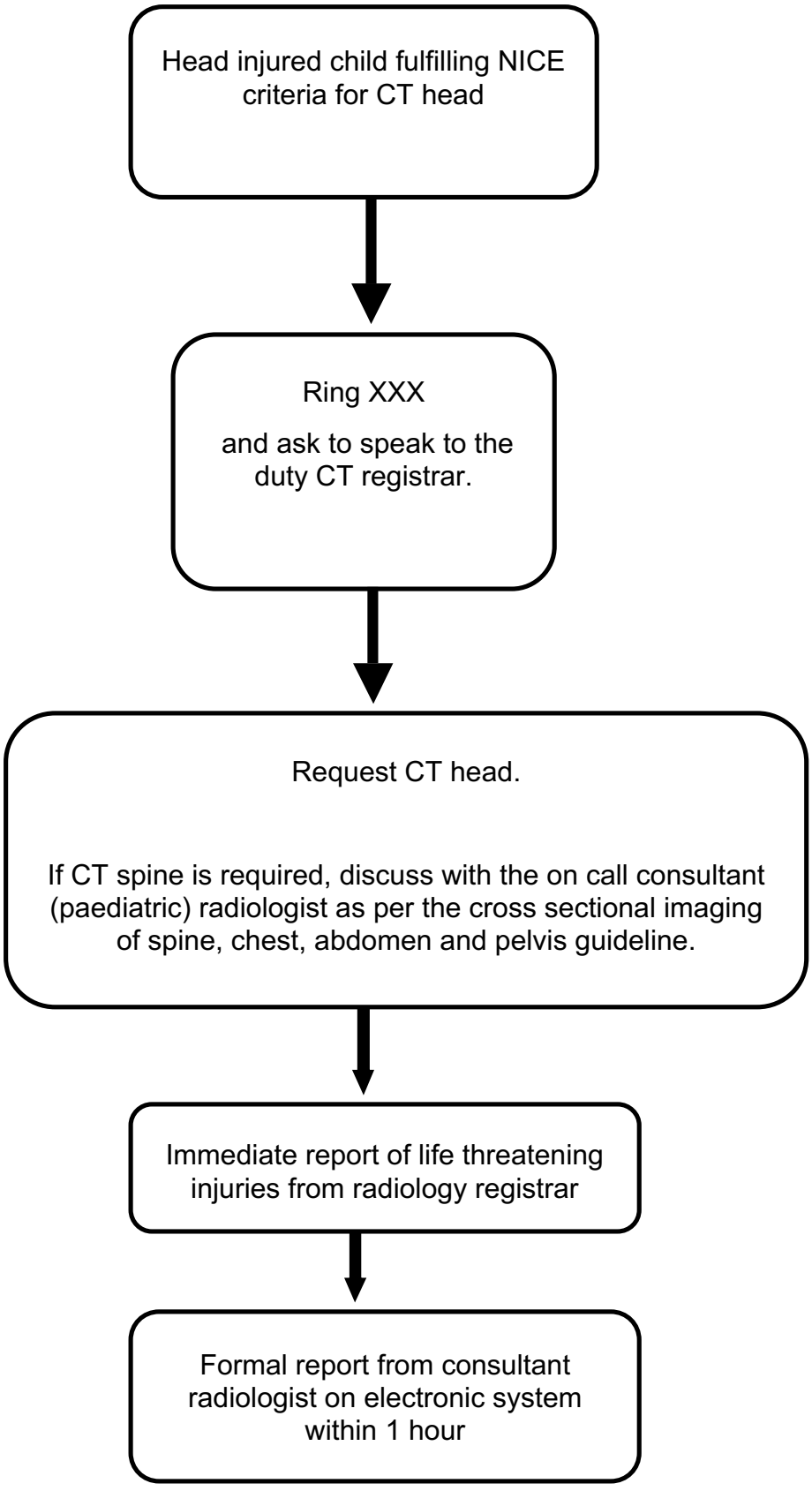
Consultant paediatric radiologist reporting of trauma imaging

Consultant paediatric radiologists at Southampton Children's Hospital will review and report on paediatric major trauma imaging. The on call paediatric radiologist can be contacted through the University Hospital Southampton switchboard.

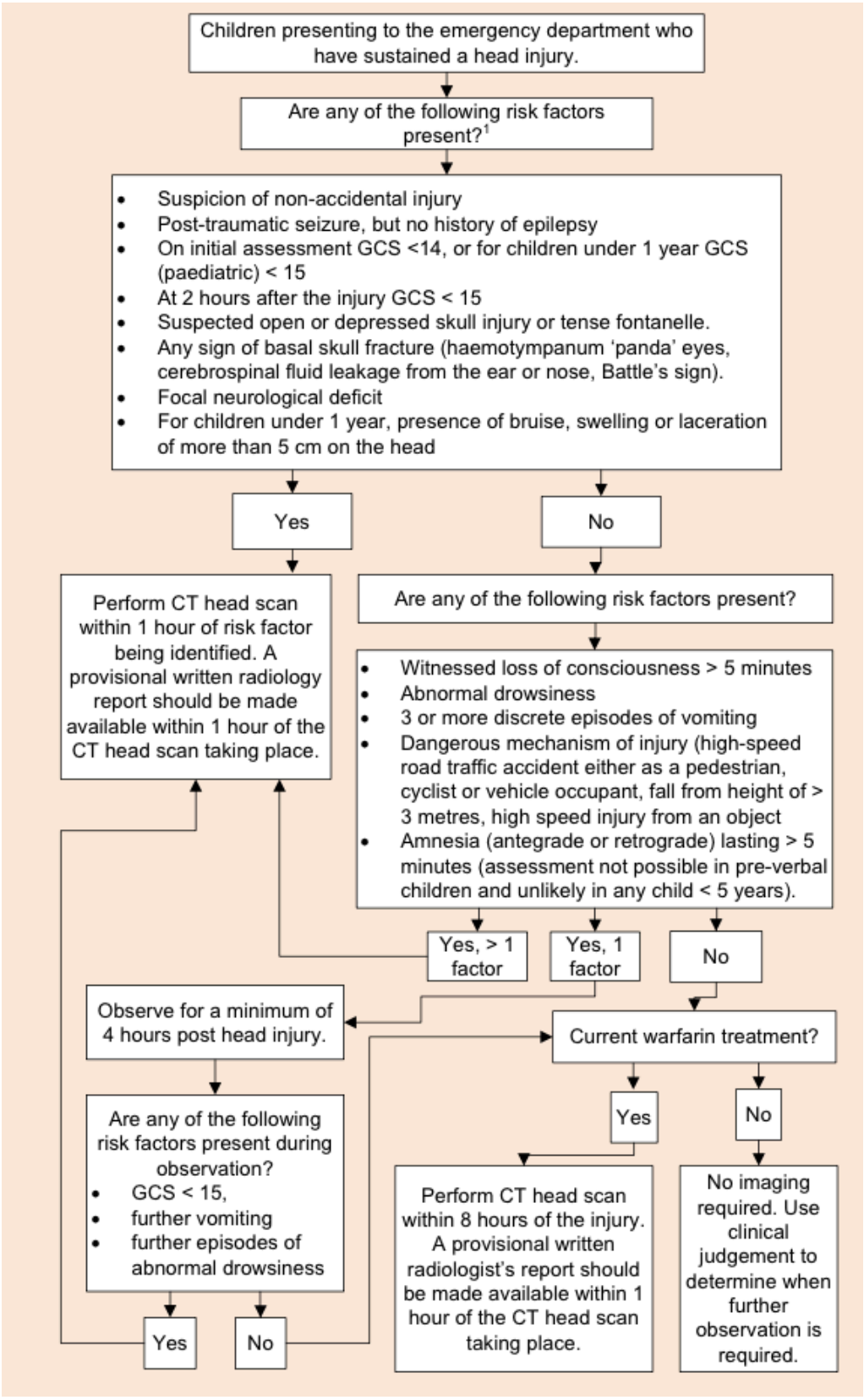
Plain imaging in all children with major trauma



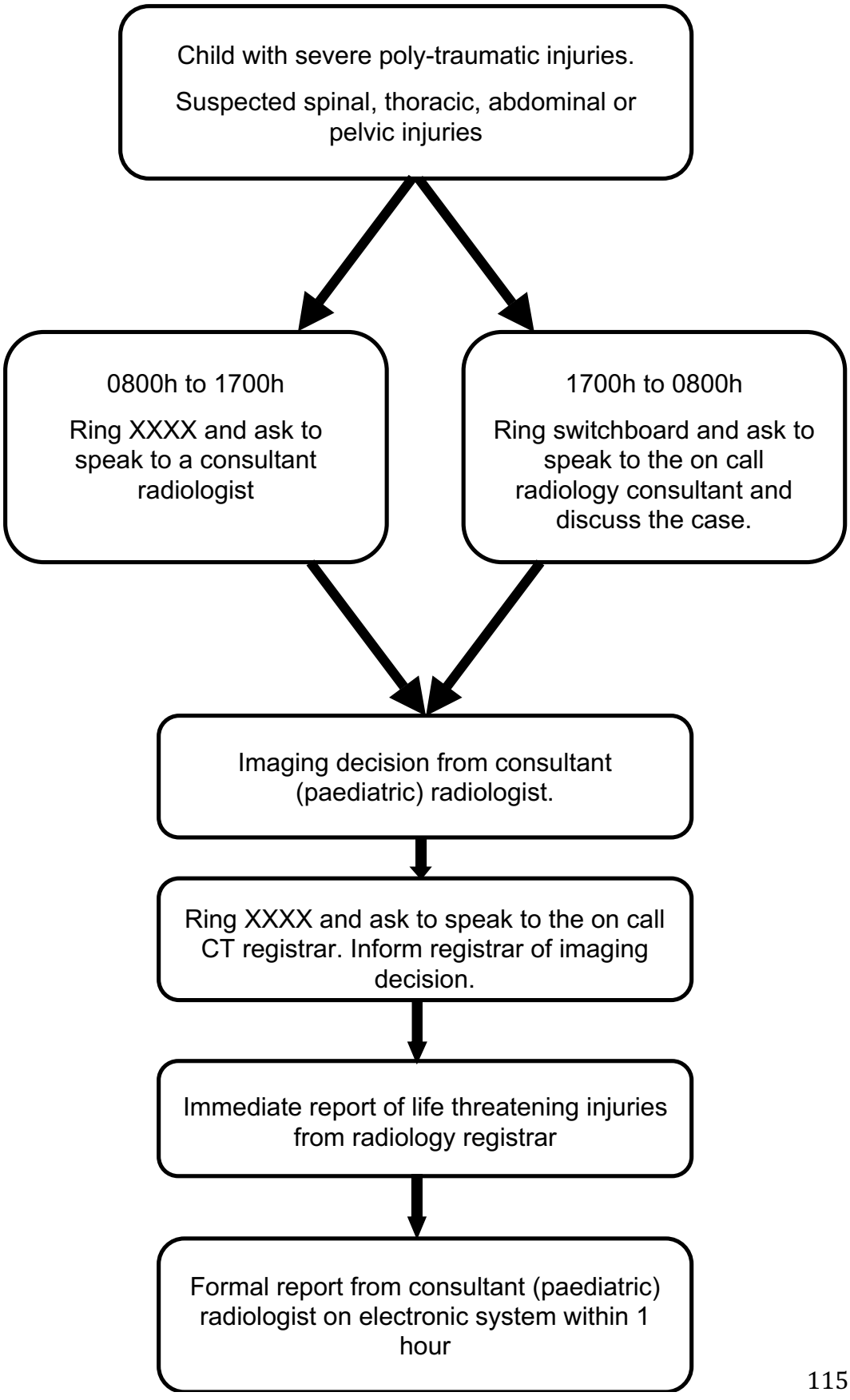
Cross sectional imaging of children with traumatic head injury



NICE guidance for selection of injured children for CT head scan

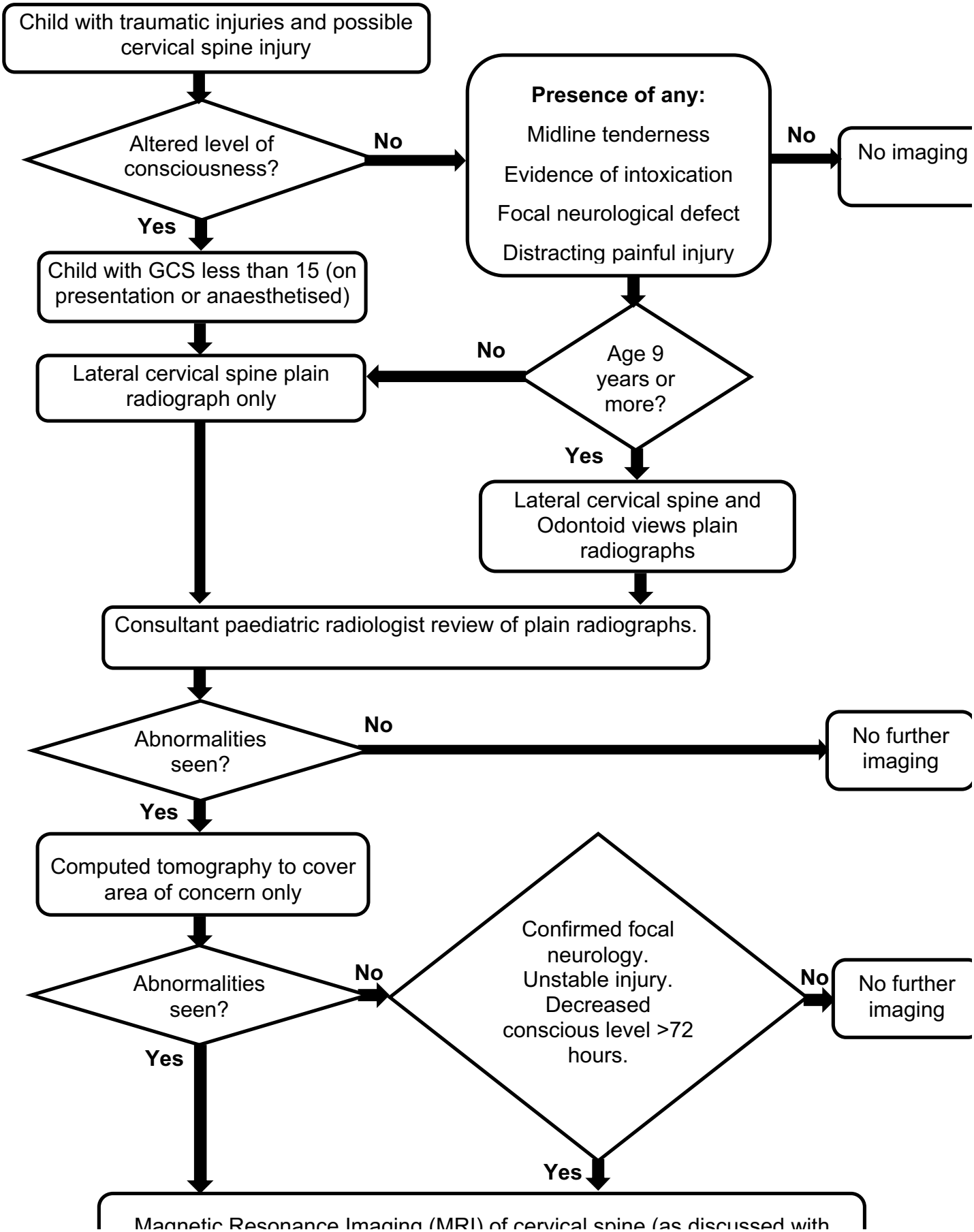


Cross sectional imaging of children with traumatic spine, chest, abdomen or pelvic injuries



Wessex children's major trauma guidelines

Pathway for cervical spine clearance for injured children



Packaging injured children for transfer within hospital

1) Ferno scoop devices are acceptable transport platforms for children.
2) Ideally the child is skin to scoop (all clothing removed).
3) The child's body is secured with straps to the Ferno scoop
4) Head blocks and tapes are appropriate for C-spine control
5) Children should have ECG, non-invasive blood pressure, pulse oximetry and end tidal carbon dioxide monitoring.
6) Warm blankets and a hat replace the removed clothing.
7) An appropriate size mask, oropharyngeal airway and self inflating bag should accompany all patients.
8) Suction and adequate oxygen supply should accompany all patients.
9) Severely injured children should have a senior doctor (ST4 or above) and skilled assistant with them at all times during transfer.

DRUGS and FLUIDS

Children's major trauma drug dose aide memoire

	Route	Child's Dose	Normal conc. of drug in vial	Suggested dilution volume	Volume of diluted solution to give a single dose	Adult dose
RESUSCITATION DRUGS						
Adrenaline 1:10,000	IV	10mcg/kg	100mcg/ml	Neat	0.1ml/kg	1mg
Dextrose 10%	IV	2ml/kg	10% dextrose	Neat	2ml/kg	N/A
Blood or FFP	IV	5ml/kg	Neat	Neat	5ml/kg	250ml
0.9% saline	IV	5ml/kg	0.9% saline	Neat	5ml/kg	250ml
ANALGESIA						
Morphine	IV	0.1mg/kg	10mg/ml	1ml drug, 9ml saline	0.1ml/kg	0.1mg/kg
Ketamine	IV	0.5mg/kg	10mg/ml	2ml drug,18ml saline	0.5ml/kg	0.5mg/kg
INDUCTION AGENTS						
Ketamine	IV	2mg/kg	10mg/ml	Neat	0.2ml/kg	2mg/kg
Thiopental	IV	2-5mg/kg	500mg powder	Powder, 20ml water	0.1-0.2ml/kg	2-5mcg/kg
MUSCLE RELAXANTS (and rocuronium reversal)						
Suxamethonium	IV	1.5mg/kg	50mg/ml	2ml drug, 8ml saline	0.15ml/kg	1.5mg/kg
Rocuronium	IV	1mg/kg	10mg/ml	Neat	0.1ml/kg	0.1mg/kg
Sugammadex	IV	16mg/kg	100mg/ml	Neat	0.16ml/kg	16mg/kg
ANTI-CONVULSANTS						
Phenytoin (over 20 minutes)	IV	20mg/kg	50mg/ml	5ml drug, 20ml saline	0.2ml/kg (over 20 mins)	1g
Lorazepam (over 3 minutes)	IV	0.1mg/kg	4mg/ml	1ml drug, 3ml saline	0.1ml/kg	4mg
OSMOTIC AGENTS (for raised intracranial pressure)						
Hypertonic saline (2.7%)	IV	5ml/kg	2.7% saline	Neat	5ml/kg	5ml/kg
Mannitol (20%)	IV	0.25g/kg	0.2g/ml	Neat	1.25ml/kg	1.25ml/kg
ANTIBIOTICS						
Cefotaxime	IV	50mg/kg	2g powder	Powder, 20ml water	0.5ml/kg	2g

	Route	Dose range	Dilutent	How to make up
SEDATION INFUSIONS				
Morphine infusion	IV	10-200 mcg/kg/hour	0.9% saline	1mg/kg morphine in 50ml saline. 1ml/hour = 20mcg/kg/hour
Midazolam infusion	IV	10-200 mcg/kg/hour	0.9% saline	1mg/kg midazolam in 50ml saline. 1ml/hour = 20mcg/kg/hour
Propofol infusion	IV	2-5 mg/kg/hour	Neat (1% propofol)	Neat propofol (1%). 2-5mg/kg/hour = 0.2-0.5ml/kg/hour
TRANEXAMIC ACID				
TXA first dose	IV	15mg/kg	0.9% saline	15mg/kg in 20ml saline delivered over 10 minutes.
TXA ongoing infusion	IV	2mg/kg/hour	0.9% saline	16mg/kg in 20ml saline delivered at a rate of 2.5ml/hour for 8 hours

REHABILITATION

Accessing paediatric rehabilitation in Wessex

Southampton Children's Hospital has a paediatric rehabilitation service funded by specialist commissioning. This is an in-patient rehabilitation service delivered by a multi-disciplinary team who work in an interdisciplinary model. There is no stand alone rehabilitation ward however the rehabilitation service benefits from its co-existence within the Children's Hospital with regards to 24 hour onsite paediatric medical cover and qualified nursing cover, immediate access to onsite paediatric tertiary specialties including neurosurgery, neuroradiology and access to the wider children's therapy staffing pool (specialist therapists within orthopaedics, respiratory and non-invasive ventilation). There is also a separate rehabilitation unit on site called Bursledon House, comprising of 12 inpatient beds (Monday - Friday). Ambulant brain injury patients transfer onto Bursledon House as part of their rehabilitation pathway to continue their rehabilitation including reintegration back into education.

Accessing the paediatric rehabilitation team from outside of Southampton Children's Hospital

To discuss referral to the paediatric rehabilitation team for inpatient rehabilitation from outside of Southampton Children's Hospital, email: Shona.mackie@uhs.nhs.uk or Michelle.geary@uhs.nhs.uk who will discuss with the multidisciplinary team and arrange to admit the patient if appropriate.

Southampton Children's Integrated Rehabilitation Team

How is rehabilitation delivered at Southampton Children's Hospital?

The rehabilitation pathway:
The same team will follow you through the pathway whilst your child is in Southampton Children's Hospital. Local hospitals often do not have the staff or facilities to maximise your child's rehabilitation and recovery during this important time. It is possible for your child to join the pathway at any of the inpatient stages depending on your child's presentation.

PICU (Intensive Care)

This is where children can be cared for whilst they are critically ill and require high levels of medical treatment and monitoring including help with breathing. Older adolescences may receive this level of care under adult intensive care settings.

↓

PHDU (High dependency)

Children can be closely monitored on this ward and receive medications that need monitoring, however children can breathe by themselves.

G-Neuro *Not all children need this ward*

Children that require neurosurgical intervention will be seen on this ward.

↓ *(Referral to local specialist service if out of area)*

PMU (Medical ward)

Children need less nursing/medical input and intermittent monitoring

During your time on PMU time your child's primary needs are therapy and education. Depending on your child's recovery at this point the best place for ongoing rehabilitation will be assessed.

Bursledon House.	Transition Service	External Rehabilitation Unit	Local DGH Inpatient Ward.
On-site specific 5 day MDT rehab unit, inpatient and day patient options. (funding approval required)	Set number of outpatient appointments (home, Local, UHS, virtual).	This may include a period at home whilst awaiting availability of bed.	This may be needed to help with complex social discharge Planning.

↓

Discharge Home +/- Community Service
These are within your locality, and will be able to link in with schools and nursery.

TRAUMA CARE EDUCATION

Trauma care education in Wessex

The Paediatric Innovation, Education and Research (PIER) Network organises the following training courses for Wessex clinicians in paediatric trauma care and critical care stabilisation and transport.

- Wessex children's trauma team training course
- Wessex thoracic trauma team training course
- Make Airway Safe Team Course (MAST)
- Stabilisation of the critically ill child course
- Simulation train the trainers course

To access these courses, contact the PIER Network administrator on:

PIER2@uhs.nhs.uk

	Item	Item size	Number of

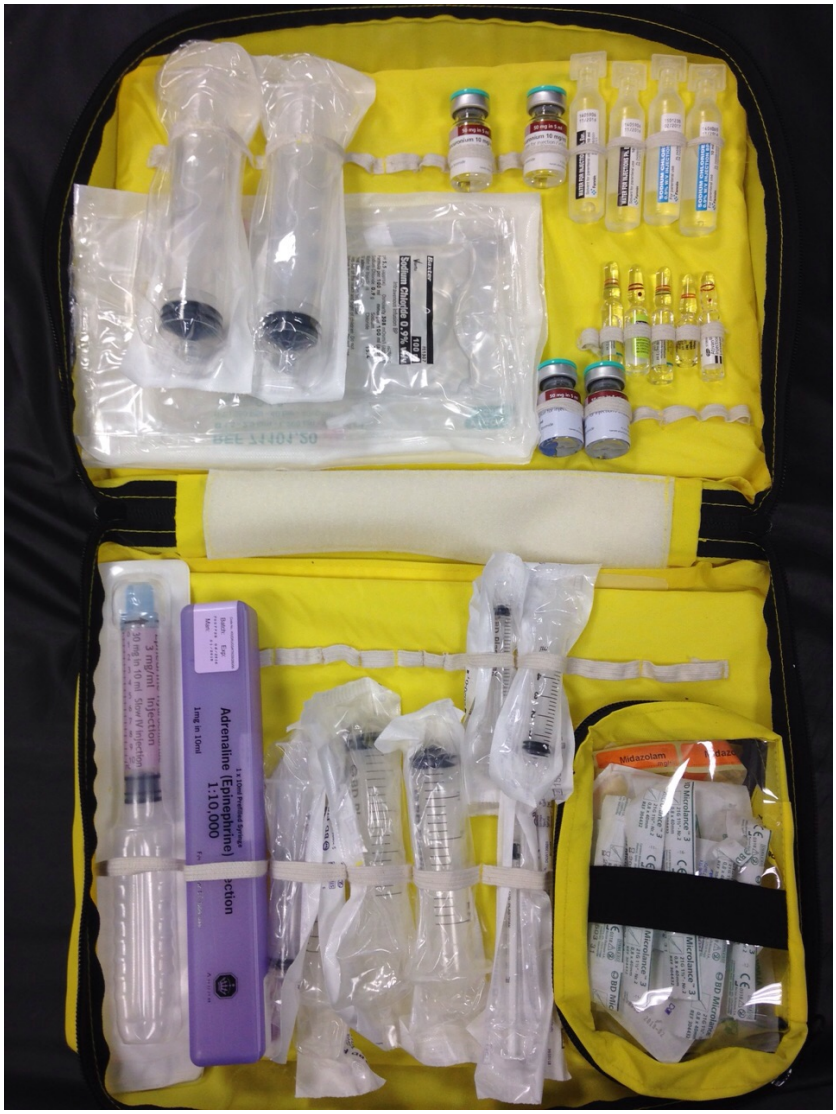
DRUG PACKS and EQUIPMENT TROLLEYS

			items
Anaesthetic drug pack 1	Drug dose aide memoire	A4	1
Anaesthetic drug Pack 2	Ketamine	10mg/ml, 20ml vial	1
	Suxamethonium	50mg/ml, 2ml vial	2
	Thiopental	500mg, powder	1
	Rocuronium	10mg/ml, 5ml vial	4
	Propofol (1%)	10mg/ml, 50ml vial	1
	Phenylepherine	100mcg/ml, 10ml vial	1
	Ephedrine	3mg/ml, 10 ml syringe	1
	Adrenaline mini jet	100mcg/ml, 10ml syringe	1
	Lorazepam	4mg/m, 1ml vial	1
	Ondansetron	2mg/ml, 2ml vial	1
	Water for injection	10ml vial	2
	0.9% sodium chloride	10ml vial	2
	0.9% sodium chloride	100ml bag	1
	1ml syringe		2
	2ml syringe		2
	5ml syringe		2
	10ml syringe		2
	20ml syringe		2
	Fentanyl sticker		2
	Morphine sticker		2
	Ketamine sticker		2
	Propofol sticker		2
	Thiopental sticker		2
	Suxamethonium sticker		2
	Rocuronium sticker		2
	Midazolam sticker		2
	Phenylepherine sticker		2
	Plain stickers	large	5
	Spike with non-return valve and bionector		1
	Alcohol wipes	large	5
	Needles	18G (green)	5
	50ml syringe		3
	200cm extension set		2
	3 way tap		1

SCH Emergency department anaesthetic drug pack contents

The drug packs are checked after every use and secured with a numbered tag to demonstrate that they are ready for use. A record of the controlled drug pack is kept in the controlled drug book by the ED staff. The clinician who receives the pack is responsible for signing the book to document the drugs that were given to the patient or safely disposed of.

	Morphine	10mg/ml, 1ml vial	1
	Midazolam	1mg/ml, 5ml vial	1
	Fentanyl	50mcg/ml, 10 ml vial	1



Example of the internal layout of drug pack 1

SCH Emergency department children's airway and breathing trolley contents

The ED paediatric equipment trolleys are checked daily by a member of the nursing staff in the resuscitation room, as per trust guidance. They have a

tagged seal to demonstrate that they have been restocked and are ready for use. If the tag is broken, they are rechecked and stocked accordingly.

Position in trolley	Name of equipment	Quantity
Side of trolley		
	1.5 litre bag-valve-mask	1
	0.5 litre bag-valve-mask	1
	Bougie size 5ch	1
	Bougie size 10ch	1
	Bougie size 15ch	1
	Stylet size 2	1
	Stylet size 4	1
	Soft suction catheter size 6	2
	Soft suction catheter size 8	2
	Soft suction catheter size 10	2
	Soft suction catheter size 12	2
	Soft suction catheter size 14	2
	Yankauer sucker, large	2
	Yankauer sucker, small	2
	Stethoscope	1
	Airway and breathing trolley contents list	1
	Airway and breathing daily trolley checklist	1
Draw 1 – masks and adjuncts		
	Mask size 00	1
	Mask size 0	1
	Mask size 1	1
	Mask size 2	1
	Mask size 3	1
	Nebuliser mask	1
	Nebuliser acorn	1
	Green oxygen tubing	1
	Reservoir oxygen mask – child	1
	Reservoir oxygen mask – adult	1
	Nasopharyngeal airway size 5	1
	Nasopharyngeal airway size 6	1
	Nasopharyngeal airway size 7	1
	NG tube size 6	1
	NG tube size 8	1
	NG tube size 10	1
	NG tube size 12	1
	Universal indicator paper	1
	NG purple syringe 50ml	1
	Lubricating jelly	1
	Oropharyngeal airway size 000	1
	Oropharyngeal airway size 00	1
	Oropharyngeal airway size 0	1
	Oropharyngeal airway size 1	1

	Oropharyngeal airway size 2	1
	Oropharyngeal airway size 3	1
	Tongue depressor	1
Draw 3 Tubes and Laryngoscopes		
	Uncuffed endotracheal tube size 2.5	1
	Uncuffed endotracheal tube size 3	1
	Uncuffed endotracheal tube size 3.5	1
	Cuffed endotracheal tube size 3	1
	Cuffed endotracheal tube size 3.5	1
	Cuffed endotracheal tube size 4	1
	Cuffed endotracheal tube size 4.5	1
	Cuffed endotracheal tube size 5	1
	Cuffed endotracheal tube size 5.5	1
	Cuffed endotracheal tube size 6	1
	Laryngoscope blade – Robert Shaw 0 (single use)	1
	Laryngoscope blade – Miller 0 (single use)	1
	Laryngoscope blade - Mac 0 (single use)	1
	Laryngoscope blade – Mac 1 (single use)	1
	Laryngoscope blade – Mac 2 (single use)	1
	Laryngoscope blade – Mac 3 (single use)	1
	Paediatric Laryngoscope handle (reusable)	2
	Stubby laryngoscope handle	1
	Elastoplast tape	1
	Cotton tape	1
	Scissors	1
	Magills forceps large	1
	Magills forceps small	1
	10ml syringe	1
	Lubricating jelly (aquagel)	2
Draw 3 – Laryngeal mask airways	LMA size 1	1
	LMA size 1.5	1
	LMA size 2	1
	LMA size 2.5	1
	LMA size 3	1
	Syringe 50ml & Aquagel	2
Draw 4 – Breathing circuits	Ayres T-piece 500ml bag	1
	Breathing system neonatal 0.8mm	1
	C-circuit 2000ml bag	1
	Catheter mount	1
	Heat moisture exchange and filter (HME –F) micro	1
	Heat moisture exchange and filter (HME	1

	–F) mini 75-200	
	Heat moisture exchange and filter (HME –F) mini 200 plus	1
Draw 5 – Needle and surgical airway	Jet insufflation pre-made kit	1
	Cannula 18G	2
	Cannula 16G	2
	Cannula 14G	2
	Syringe 10ml	1
	0.9% saline 10ml	2
	Scalpel size 10	1
	Forceps, small	1
	Spare batteries AA x2	2

SCH Emergency department children's circulation trolley contents

Position in trolley	Name of equipment	Quantity
Top of trolley	Hypoglycaemia investigation pack	1
Side of trolley	Circulation trolley contents list	1
	Circulation trolley daily checklist	1
	Children's major trauma guidelines	1
	SUHT medical emergency audit form	1
Draw 1 – Peripheral intravenous access	Jelco cannula size 24G (yellow)	6
	Jelco cannula size 22G (blue)	6
	Jelco Cannula size 20G (pink)	6
	Jelco cannula size 18G (green)	6
	Jelco cannula size 16G (grey)	6
	Jelco cannula size 14G (brown)	6
	Tegaderm IV dressing large	6
	Tegaderm IV dressing small	6
Draw 2 - blood bottles, needles, splints	3 way tap	2
	T-piece	4
	0.9% saline 5ml	5
	White bungs	5
	Needles - orange	5
	Needles Blue	5
	Needles Green	5
	Gauze squares	5
	Tourniquet	2
	Wee light	1
	Razor	2
	Scalp cannula cover	2
	Arm splint neonatal	2
	Arm splint infant	2
	Arm splint child	2
	Bandages small	2
	Steristrips	6
	Yellow top blood bottle, lithium heparin	2
	Purple top blood bottle, EDTA	2

Draw 2 continued	Blue top blood bottle, sodium citrate	2
	Red top blood bottle, plain	2
	Grey top blood bottle, fluoride oxalate	2
	Blood culture bottles	2
Draw 3 - syringes/ABG	Blood gas capillary tubes	5
	Blood gas syringe	2
	Capillary sample lancets	5
	1ml syringe	5
	2ml syringe	5
	5ml syringe	5
	10ml syringe	5
	20ml syringe	5
	50ml syringe	5
Draw 4 – EZIO/Leadercath	EZIO driver	1
	EZIO needles for 3-39kg (pink)	2
	EZIO needles for >40Kg (blue)	2
	Small forceps	1
	Elastoplast tape	1
	Chloroprep large swabs	2
	Ledercath size 20G 8cm	2
	Tegaderm IV dressing	4
Draw 5 – Pelvic splint, major haemorrhage/HAS	Pelvic binder	2
	Arterial Tourniquets (CAT)	2
	Celox ribbon gauze	2
	Human albumin solution 4.5%, 250ml	4

SCH Emergency department children's procedures trolley contents

Position in trolley	Name of equipment	Quantity
Draw 1 - Sterile procedures kit	Dressing pack	2
	Sterile sheets – plain	2
	Sterile gloves - small	1
	Sterile gloves - medium	1
	Sterile gloves - large	1
	Sterile gowns	2
	Chloroprep – large swabs	2
Draw 2 - Urinary catheterisation	NG feeding tube size 5	2
	Foley catheter size 6	2
	Foley catheter size 8	2
	Foley catheter size 10	2
	Foley catheter size 12	2
	Catheter pack	1
	Steristrips – medium size	4
	0.9% Saline 10ml	2
	Urometer	1
Draw 3 – Arterial line	Jelco cannula 24G	2
	Jelco cannula 22G	2
	Jelco cannula 20G	2
	T-piece connectors	2
	Small tegaderm IV dressing	2
	0.9% saline 10ml	2
	Babywire	2
	Syringe 1ml, non-luer lock	2
	Syringe 2ml, non-luer lock	2
	Syringe 5ml, non-luer lock	2

Draw 4 – Central line	Paediatric central line sterile insertion pack	1
	Triple lumen central line 5F, 5cm	1
	Triple lumen central line 5F, 8cm	1

	Triple lumen central line 5F, 15cm	1
Draw 5 – Central and arterial pressure monitoring	500ml Pressure bag	1
	Heparin sodium 500ml	1
	Pressure transducer double lumen	1
	Transducer cable	1
Draw 6 – Chest drainage	Seldinger chest drain 8F	1
	Seldinger chest drain 10F	1
	Seldinger chest drain 12F	1
	Seldinger chest drain 14F	1
	Luer lock adaptor	2
	Underwater drainage system	1
	Bottle sterile water	1
	Box 2.0 sutures – straight needle	1
	Box size 10 scalpels	1
	Large IV 3000 dressing	2
	Large chloraprep sticks	2
	Small spencer wells forceps	1

Babypac ventilator grab bag contents

Name of equipment	Number in pack
Babypac ventilator with oxygen and air cables attached 	1
Babypac ventilator tubing 	1
HME (white) 	1
HMEF (small green) (TV 75-200ml) 	1
Test lung	1

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