London Major Trauma System

NHS
London
Operational Delivery Networks

London Major Trauma System:

Paediatric Trauma Manual

March 2020

Contents

Contributors

Contributors

Ruth Bird – *Paediatric Trauma Fellow, Royal London Hospital*

Naomi Edmonds – *Paediatric Intensive Care and Anaesthetic Consultant, Royal London Hospital*

Breda O'Neill – *Paediatric Anaesthetic Consultant, Royal London Hospital*

Elaine Cole – *Director of Research and Innovation, Pan London Major Trauma System*

Ceri Elbourne – *Surgical SPR and Darzi Fellow, Royal London Hospital*

Daniel Braunold - *Paediatric Anaesthetic Trauma Fellow, Royal London Hospital*

Michael Carver – *Lead Nurse for Violence Reduction, Emergency Care and Trauma. Royal London Hospital*

Kevin Enright – *Anaesthetic and Pre-hospital Care Consultant, St Georges Hospital*

Erica Makin – Paediatric Surgical Consultant, *Kings College Hospital* London

Rebecca Salter – *Paediatric Emergency Department Consultant, St Mary's Hospital*

Asif Rahman – *Emergency Department Consultant, St Mary's* Hospital

Derek Hicks – *Emergency Department Consultant, Royal London Hospital*

Dean Rex – *Paediatric Surgical Consultant, St Georges Hospital*

Anthony Hudson – *Emergency Department Consultant, St Georges Hospital*

Emma Rowlands – *Emergency Department Consultant, Homerton Hospital*

Thomas Breen - *Paediatric Anaesthetic Consultant, St Georges Hospital*

Karim Brohi – *Professor of Trauma Sciences, Queen Mary's University of London, Clinical Director, London Major Trauma System.*

Ross Davenport – Consultant Trauma and Vascular Surgeon, Senior Lecturer in Trauma Sciences, Royal London Hospital

Jo Challands – *Paediatric Anaesthetic Consultant, Royal London Hospital*

Ulrikke Sigg – Clinical Nurse Specialist Pain, Royal London Hospital

Ambia Ali - Clinical Nurse Specialist Pain, Royal London Hospital

Dan Nevin - *Anaesthetic and HEMS Consultant, Royal London Hospital*

Ann Weaver – *Clinical Director, Royal London MTC, Emergency Department & HEMS Consultant, Royal London Hospital*
Nigel Tai – *Consultant Trauma & Vascular Surgeon, Royal London Hospital*
Laura Green – *Consultant Haematologist, Royal London Hospital*
Shuba Allard – *Consultant Haematologist, Royal London Hospital*
Nick Bunker – *ICU Consultant, Royal London Hospital*
Gareth Grier – *Emergency Department & HEMS Consultant, Royal London Hospital*
Raksa Tupprasoot – *Paediatric Anaesthetic Consultant, Evelina Childrens Hospital*
Corinne Stannard - *Paediatric Anaesthetic Consultant, Royal London Hospital*
Jess Ng - *Surgical Registrar & Darzi Fellow, Royal London Hospital*
Stewart Cleeve – *Paediatric Surgical Consultant, Royal London Hospital*
Martin Griffiths – *Consultant Trauma & Vascular Surgeon, Royal London Hospital*
Ross Davenport - *Consultant Trauma & Vascular Surgeon, Royal London Hospital*
Tom Konig - *Consultant Trauma & Vascular Surgeon, Royal London Hospital*
Rosel Tallach - *Consultant Anaesthetist, Royal London Hospital*
Sumitra Lahiri - *Consultant Anaesthetist, Royal London Hospital*
Tim Egan - *Consultant Anaesthetist, Royal London Hospital*
Neal Durge – *Emergency Department Consultant, Royal London Hospital*
Chris Uff – *Consultant for Neurotrauma, Royal London Hospital*
Suresh Pushpanathan - *Consultant Neurosurgeon, Royal London Hospital*
Giles Armstrong – *Paediatric Emergency Department Consultant, Royal London Hospital*

Particular mention and thanks to Dr Matthew Heron, anaesthetic registrar for the excellent original illustrations incorporated throughout this text

Written Parental/Child consent obtained for use of all cover photos.

The London Major Trauma System has issued these guidelines for the benefit of any healthcare professional working in paediatric trauma. The information within this guidance is for educational purposes and is not a substitute for senior medical advice, experience or judgement. It is not intended as a substitute for local trust policies and procedures. We cannot accept liability for the misuse of these guidelines in any fashion.

Whilst the content has been reviewed by several experts, we recognise that errors may be present. We will request feedback prior to the next review of this guidance document.

Abbreviations

List of abbreviations

A

A&E – Accident and Emergency Department

AAST - American Association of Trauma Surgeons

APA – Association of Paediatric Anaesthetists

B

BM – Blood Sugar

BMV – Bag Valve Mask (self- inflating)

C

CATS – Children's Acute Transport Service

CBRN - Chemical Biological Radiological Nuclear

CSL – Compound Sodium Lactate

CT – Computer Tomography

CVC – Central Venous Catheter

CVVH - Continuous Veno-Veno Haemofiltration

CXR – Chest X-Ray

D

DCR – Damage Control Resuscitation

DCS – Damage Control Surgery

DAS - Difficult Airway Society

E

ED – Emergency Department

ETCO2 – End Tidal Carbon Dioxide

ETT – Endotracheal Tube

F

Fi02 – Inspired Oxygen Content (%)

FFP – Fresh Frozen Plasma

G

GCS – Glasgow Coma Scale (3-15)

G&S – Group and Save

I

IO – Intraosseous

IM – Intramuscular

IR – Interventional Radiology

IV – Intravenous

K

KPa - kilopascal – Measurement of pressure

K+ - Potassium

L

LAS - London Ambulance Service

LFT – Liver Function Tests

M

MI – Major Incident

MTC - Major Trauma Centres

N

NaCl – Normal Saline (sodium chloride)

NELETN – North East London Essex Trauma Network

NAI – Non Accidental Injury

NCA - Nurse Controlled Analgesia

O

ODP – Operating Department Practitioner

OPSI – Overwhelming Post Splenectomy Infection

P

PCA - Patient Controlled Analgesia

PEEP – Positive End Expiratory Pressure

PICU – Paediatric Intensive Care Unit

R

RCPCH – Royal College of Paediatrics and Child Health

RCR – Royal College of Radiologists

S

Sp02 – Oxygen Saturation

SpR – Specialist Registrar

STRS – South Thames Retrieval Service

T

TBSA – Total Burn Surface Area

TCA – Traumatic Cardiac Arrest

TU - Trauma Units

TXA – Tranexamic Acid

U

U&E – Urea and Electrolytes

INTRODUCTION

This document provides an overview of Paediatric Trauma management with gold standards for practice, regardless of location. It is a guide to providing care for the sickest trauma patients so that skills and knowledge are maintained across trauma systems, thus ensuring safe delivery of care. Local policy must always be taken into consideration.

1.1 Trauma Systems

Trauma systems provide a continuum of care for all injured patients within a geographical location. This 'inclusive' approach to trauma care involves collaboration between prehospital services, hospitals within the region, community providers and the government.

Within trauma systems, hospitals receiving trauma patients are designated as either Major Trauma Centres (MTCs) or Trauma Units (TUs). MTCs have resources available 24 hours a day to manage severely injured patients, whilst trauma units are responsible for the local management of patients with potentially less severe injuries. However, evidence shows that more seriously injured patients do not always present at major trauma centres. As a consequence, it is important that skills and knowledge are maintained across trauma systems to ensure safe delivery of care. TUs should be capable of performing lifesaving interventions for any major trauma patient that is too unstable for transfer directly to the MTC.

1.2 The Pan London Major Trauma System: Paediatric Trauma

Injury is the leading cause of death in children and adults up to the age of 44 years in England and Wales[1]. Evidence shows that trauma systems improve patient outcomes [2, 34] yet trauma is the principal cause of morbidity and mortality in the under 18's. Boys are more likely to be injured than girls, especially during adolescence when they are three times more likely to die from injury than their female counterparts (RCPCH).

Injury occurs at all ages in children and young adults with a bimodal distribution in the under twos and adolescents. Despite the establishment of the Pan

London Major Trauma System and sophisticated ambulance triage tools, there is evidence that up to 50% of children with significant trauma still present to trauma units and local emergency departments (EDs) rather than MTC's. Some of these cases bypass the pre-hospital trauma triage systems through self-presentation.

In the under twos, falls or drops from height are the most common mechanism of injury, overtaking road traffic collisions (RTCs), which have declined secondary to heath prevention measures, seatbelts, speed limitations, cycle safety schemes, helmets etc.

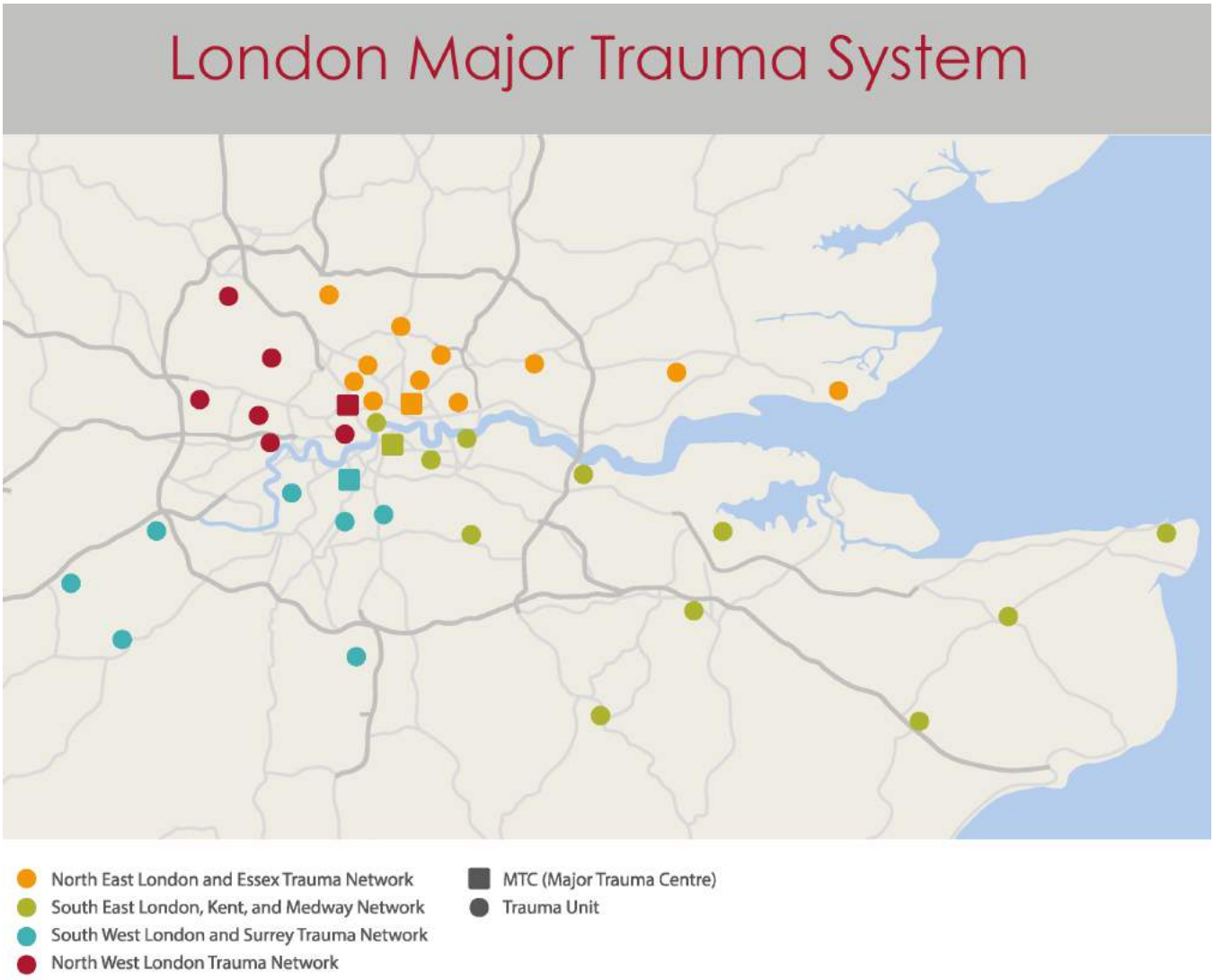
Paediatric patients encompass a group from infancy to adulthood with attendant range of psychosocial factors associated with their injury. A holistic family centred approach to care improves co-operation, experience and overall wellbeing. Clinicians should ensure safeguarding measures are addressed in all age groups with special consideration given to the patients younger than one year.

Historically, blunt trauma has been the most common mechanism of injury in paediatric trauma. However, there has been a significant rise in penetrating trauma in the adolescent group with victims of assault presenting earlier with more significant injuries. This has led to an increased presentation of major haemorrhage in children with specific protocols devised to assist in their management.

1.3 The Pan London Major Trauma System

The Pan London Major Trauma System was introduced in April 2010, the first area of the UK to provide regional trauma care.[1] In 2012 trauma networks were implemented across England. Eleven of these are co-located adult and paediatric units, eleven treat adults alone and five are solely paediatric. Most trauma networks operate automatic acceptance policies where the MTC provides care for trauma patients within the network/region as needed. In order to maximise the capacity of the system and ensure flow of patients, effective repatriation of patients from the MTC to their local TU for ongoing rehabilitation is

required. The network based system has been shown to significantly improve the quality of care to major trauma patients, most notably for the critically injured in whom mortality rates have halved. [2,34,35]



The Pan London Major Trauma System consists of four networks:

1. North East London and Essex Trauma Network (NELETN) (MTC Royal London Hospital)
2. South East London, Kent and Medway Networks (SELKAM) (MTC Kings College Hospital)
3. South West London and Surrey Trauma Network (SWLSTN) (MTC St Georges Hospital)

4. North West London Trauma Network (NWLTN) (MTC St Mary's Hospital)

The above map shows how the networks are spread out across London.

The Trauma Units within each network include:

1. NELETN:

Queens Hospital Romford, Basildon, Southend, Newham, Whipps Cross, Homerton, Whittington, North Middlesex, University College London Hospital (UCLH), The Royal Free, Barnet.

2. SELKAM

Medway, Maidstone, Tunbridge Wells, William Harvey, Kent and Canterbury, Queen Elizabeth Queen Mother hospital, Princess Royal Orpington, Lewisham, Queen Elizabeth, Darent Valley, St Thomas's.

3. SWLSTN:

Kingston, St Helier, Croydon, St Peters Chertsey, Frimley Park, Royal Surrey County, East Surrey.

4. NWLTN

Northwick Park, Watford General, Hillingdon, Ealing, West Middlesex, Chelsea and Westminster.

1.4 The Paediatric Trauma Team

Individual variation will exist between Major Trauma Centres and Trauma Units as to who attends and leads paediatric trauma calls. In the MTC a specialised trauma team is available 24/7, with a Consultant presence to lead or advise the team.

Paediatric trauma within the pan London system is co-located with adult trauma. This supports collaboration between adult and paediatric services, with supporting specialty Consultant presence at advanced, complex calls such as significant neurotrauma or major haemorrhage.

At the MTC, the designation of the paediatric trauma team is outlined as follows:

Trauma Team Leader
ED Registrar/Consultant
ED Nurse
Paediatric Nurse
Paediatric Anaesthetist SpR/Consultant*
ODP/Anaesthetic nurse
Paediatrician
Ortho SpR
Porter
Duty Radiographer / Consultant Radiologist reporting*
General Surgical SpR (Paediatric Surgical in MTC) / Consultant*
PICU SpR/PCCU Consultant* (not always first responders)
Neuro SpR/Consultant* (call dependent)

(* for Major Haemorrhage (Code Red) / Major Neurosurgical Trauma (Code Black)

TUs will have some of the above but are mandated to have a team leader ST3 or above with ATLS training (or equivalent) and another clinician trained in APLS. [2]

Following the primary survey all patients should have a secondary survey completed in ED and tertiary survey clearly documented prior to discharge. The Paediatric team should be present and lead on safeguarding pathways, ensuring these protocols are followed.

1.5 Who Do These Guidelines Apply To?

This is a collaborative document open to anyone managing paediatric trauma across greater London.

Key Principles: In Managing Children

Rapport and cooperation from the patient are vital, so tactics to put the child at ease such as involvement of play therapists, dedicated nurses and distraction help focus on non-medical aspects of management.

Analgesia appropriate for the child's weight/injury severity should be given early to help aid assessment. In the absence of IV access consider Intranasal/Buccal preparations.

Significant injury can be masked in the "apparently uninjured child." Serious mechanisms of injury should prompt careful consideration for further imaging.

Safeguarding concerns should be raised for any injured child under 1 or if there is any suspicion of non-accidental injury (NAI) in older children. The paediatric team should be present and lead on safeguarding pathways, ensuring these protocols are followed.

Children can be managed by trained clinicians, using APLS and ATLS principals.

Paediatric trauma patients should be reviewed by a Consultant with expertise in paediatrics.

Network pathways should be followed for MTC consultation as appropriate.

Attention to detail around fluid balance, warmth, and glucose levels is essential.

The initial compensatory mechanisms in paediatric patients are much better than adults.

Hypotension and tachycardia are relatively late signs of shock; use clinical judgement in management of injuries.

Persistent abnormal vital signs suggest serious missed injury.

In uncontrolled haemorrhage, consider Damage Control Surgery/Damage Controlled Resuscitation.

Traumatic Cardiac Arrest: the arrested paediatric patient with an empty heart responds to simple filling better than adult patients. There should be no delay in the administration of haemostatic resuscitation.

Following the primary survey all patients should have a secondary survey completed in ED. A tertiary survey should be completed prior to discharge.

2. CLINICAL GUIDELINES

2.1 MTC Triage Criteria for Ambulance Services[3]

Ambulance services, guided by triage tools, have become expert at delivering seriously injured children to the correct destination, however many children will still present to TU's either via missed/hidden injuries or via self-presentation. Multiple ambulance providers serve the pan-London region and there is variation in their local guidance. For example, NELETN East of England and London Ambulance Service (LAS) have different trauma triage tools though there are common themes, as illustrated below.

Table 1: MTC Triage Criteria for the Ambulance services (*local policies may differ)

VITAL SIGNS
Abnormal vital signs (not explained by crying or pain response)
GCS ≤ 13 or inappropriate behavior post injury
TYPE OF INJURY
General
Traumatic amputation
Penetrating trauma
Signs of bruising to chest/abdomen
Ortho/Neuro
Spinal trauma with abnormal neurology
Suspected pelvic fracture
Open long bone fracture / Multiple long bone fractures
Skull fracture
Burns
Burns/scald > 20% (if less than 12yrs 30% if 12-18)
Facial burns
Circumferential burns
Special Considerations Bleeding Disorders / anticoagulation

2.2 Admission to a Trauma Unit

Admission to a TU includes trauma that falls outside the above criteria or isolated injury, such as that sustained to head or long bones.
Triage Criteria for London Air Ambulance Service works on either immediate or interrogated dispatch criteria as illustrated below (* local policies may differ).
Activation does not necessarily dictate transfer to MTC.
Immediate dispatch criteria include: -

Fall from greater than 2 floors (>20 feet)
'One under' (fall or jumped in front of a train)
Ejected from vehicle
Death of a same vehicle occupant
Amputation above wrist or ankle
Trapped under vehicle (not motorcycle)
Or by request from other emergency services (including the RNLI / coastguard)

Interrogated (call monitoring or via direct communication) dispatch criteria include: -

Penetrating Trauma (shooting, stabbing, explosions)
Road Traffic Collisions
Industrial accidents/incidents or building site accidents
Hanging
Drowning
Entrapments
Amputations
Burns/scalds
Falls from height less than 2 floors
Impaled on an object

3. CLINICAL GUIDELINES: CORE TOPICS

3.1. NEUROTRAUMA

3.1.1 Neurotrauma at the MTC

Certain processes should be followed when a child with significant neurotrauma is expected:

A pre-alert will have been received and a specialised trauma team assembled

Neurosurgery team should be contacted

PCCU team alert

Time critical neurotrauma should be performed immediately at the MTC with neuroprotective measures instituted to prevent secondary injury

Theatre teams should be made aware to ensure rapid transfer of patient to theatre from Emergency Department/CT scan

A definitive airway should be secured, if required, to facilitate safe scanning

CT imaging of the brain should be obtained within 30 minutes of arrival

Primary and secondary survey should be completed in all patients

Be prepared for major haemorrhage in conjunction with severe head trauma

Utilise CATS/STRS for transfer post operatively if no local PCCU available or if ongoing neurocritical care is not available

In non "time-critical" neurosurgical injury, teams should liaise with paediatric neurosurgical centres or simultaneously if time permits

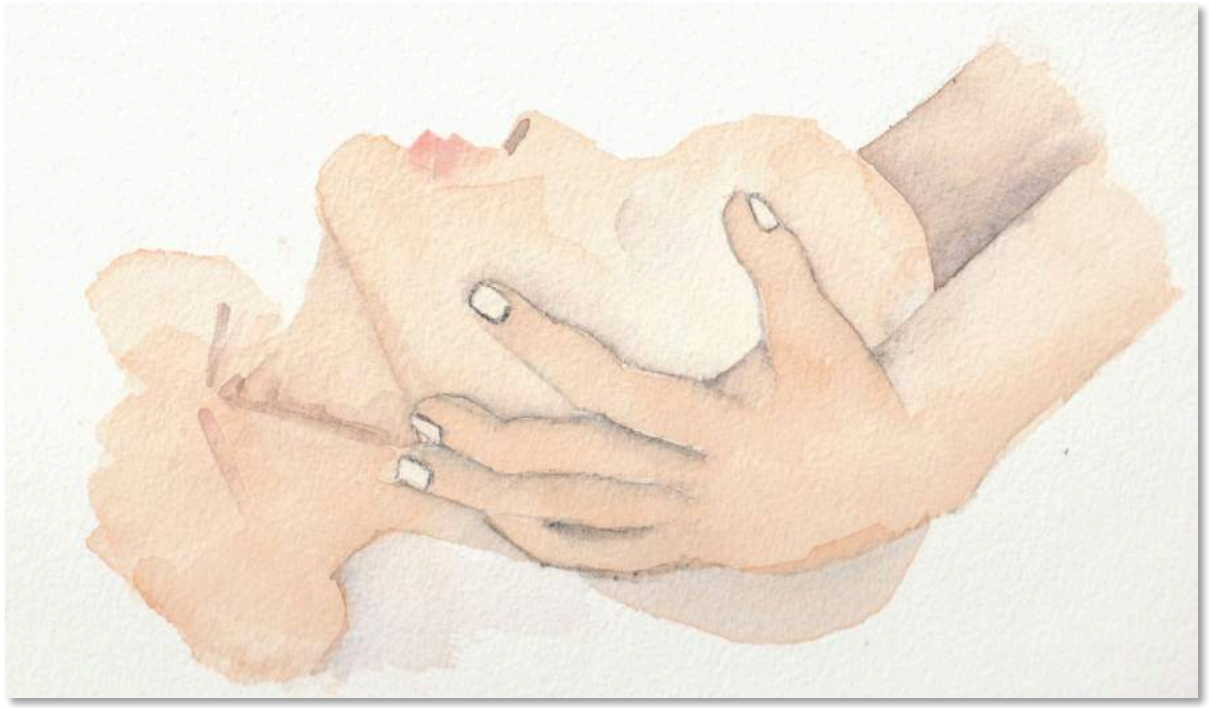
3.1.2 Paediatric Neurotrauma/Neurosurgery

Focused primary survey and CT imaging of the head, neck, chest, abdomen and pelvis where polytrauma expected. Identify and treat life threatening extra cranial injury
Aim for CT Imaging of the brain within 30 minutes of arrival
Radiological Clearance of the cervical spine and removal of the cervical collar will avoid occlusion of jugular veins and allow movement of the neck for subsequent interventions [14]
Intra-operatively – prepare for the possibility of massive haemorrhage. Ensure 2 x large bore IV access with group and save sent prior to transfusion. Use group O blood if crossmatch unavailable. In the event of massive haemorrhage give TXA and monitor calcium
Prevention of Secondary Brain Insult: careful intubation & ventilation optimise ventilation aiming to keep ETCO2 4.6-5.0 kPa avoiding high PEEP avoid hypotension keeping the child's MAP normal for child's age** (see appendix) avoid hypertension from direct laryngoscopy (consider opiates at induction) if associated haemorrhage, resuscitate whilst maintaining MAP within 10% of normal for age maintain normothermia and normoglycaemia evidence of herniation: administer 3ml/kg 3% hypertonic saline or mannitol (as per local guidelines)
Seizure management: if evidence of seizures, administer Phenytoin or Levetiracetam (as per local policy)
Evacuation of appropriate mass lesions demonstrated on CT: follow local neurotrauma pathway

3.1.3 Anaesthetic Considerations In all Trauma patients

Preparation	**Induction**	**Intubation**	**Post Intubation**
Team Brief Trauma ODP Senior help aware Complete checklist (ensure equipment available including suction and self-inflating BVM) Allocate roles and discuss plan for induction and intubation with the team (Follow DAS/APA guidelines) [4]	Secure intravenous access with IV resuscitation as appropriate ECG, BP, ETCO2 & SaO2 monitoring Pre-oxygenation/high flow oxygenation if tolerated Consider Fentanyl, (1-3mcg/kg) to obtund stimulus from laryngoscopy avoiding spikes in ICP Consider Ketamine (1-2mg/kg) * *(safe in neuro trauma)* Rocuronium (1mg/kg) * although cautious use of other agents can be considered Potential for haemodynamic instability: have emergency drugs and fluid resuscitation available * Dose reduction may be required if haemodynamic instability	Optimise position whilst maintaining manual in-line stabilisation Passive oxygenation with nasal specs during intubation is an option Cricoid pressure Low threshold to use intubation adjuncts cautiously Restrict intubation attempts to <30 secs to avoid desaturation Adhere to DAS guidelines where difficulty encountered Use cuffed ETT	Secure ET tube with tape Maintain IV sedation and analgesia +/- paralysis Ventilation as above Titrate FiO2 Consider arterial line/CVC but avoid delay to CT or theatre Ensure IV lines visible if running TIVA Ensure analgesia bolus eg Fentanyl before neurosurgeon secure pins for Mayfield ring in theatre Monitor Temperature Keep normothermic Warm fluids

Image 1: Manual In-line Stabilisation



Tips for Induction

Trauma patients may be unstable at induction of anaesthesia

Children compensate well. Tachycardia/hypotension are late signs of shock/hypovolaemia

Be wary of the tachycardic child (rule out pain)

Preparation is key. Ensure adequate IV/IO access x 2, resuscitate prior to induction or simultaneously if major haemorrhage

Ensure preloading prior to induction 10mls/kg (blood/ FFP/ Isotonic fluid such as *Hartmann's solution* if not bleeding) – hypovolaemia/low output is a serious cause of arrest during induction to the inexperienced paediatric anaesthetist

Use drugs that you are comfortable with in complex emergency situations

Cautiously titrate Propofol if used in major haemorrhage (high dose opiate such as Fentanyl recommended)

Check ETT position - below cords and be wary of endo-bronchial intubation

If anaesthetising outside of theatre, use cautious bolus or low dose propofol, and if tolerated continue for transfer

Theatre: key points for consideration

Ensure 2 x G&S sent, ideally prior to transfusion
Ensure consent form if for operative procedure
Ensure 2 patient wristbands
Continue management of neurotrauma patient avoiding secondary brain injury.
Volatile anaesthesia; you may need to target a lower MAC titrated to BP
Continue to administer opiates for anaesthesia

Post-op

Maintain anaesthesia as per local PCCU policy. Utilise CATS/STRs Transfer guidelines post operatively if no local PCCU/awaiting transfer

3.1.4 NICE Guidelines for CT Scan in Head Injury

3.1.4 a: For children who have sustained a head injury and have any of the following risk factors, perform a CT head scan within 1 hour of the risk factor being identified:
Suspicion of non-accidental injury
Post-traumatic seizure but no history of epilepsy
On initial emergency department assessment, GCS less than 14, or for children <1 year, GCS less than 15
At 2 hours after the injury, GCS less than 15
Suspected open or depressed skull fracture or tense fontanelle
Any sign of basal skull fracture (haemotympanum, 'panda' eyes, cerebrospinal fluid leakage from the ear or nose, Battle's sign)
Focal neurological deficit
For children under 1 year, presence of bruise, swelling or laceration of more than 5 cm on the head.

3.1.4 b: For children who have sustained a head injury and have **more than 1** of the following risk factors (and none of those above in 1.3), **perform a CT head scan within 1 hour** of the risk factors being identified:

Loss of consciousness lasting more than 5 minutes (witnessed)

Abnormal drowsiness

Three or more discrete episodes of vomiting

Dangerous mechanism of injury (high-speed road traffic accident either as pedestrian, cyclist or vehicle occupant, fall from a height of greater than 3 metres, high-speed injury from a projectile or other object)

Amnesia (antegrade or retrograde) lasting more than 5 minutes[4].

3.1.4c: Children who have sustained a head injury and have **only 1** of the risk factors in recommendation 1.3.4 b (and none of those in recommendation 1.3.4 a) should be **observed for a minimum of 4 hours** after the head injury. If during observation any of the risk factors below are identified, perform a CT head scan within 1 hour:

1. GCS less than 15
2. Further vomiting
3. A further episode of abnormal drowsiness

A provisional written radiology report should be made available within 1 hour of the scan being performed. If none of these risk factors occur during observation, use clinical judgement to determine whether a longer period of observation is needed [5]

Criteria for admission with head injury:

1. CT findings suggesting fractures, contusions, or intra-cerebral bleed
2. Signs of neurological dysfunction
3. Severe headache or vomiting
4. Presence of serious clotting disorders such as haemophilia, anticoagulant therapy
5. Difficult social conditions at home, unable to re-present quickly or a lack of a responsible adult to carry out observations after discharge from hospital

6. Difficulty in assessing the neurology due to young age or uncooperative behaviour

3.1.5 Neurotrauma at the Trauma Unit

Principles of management are as above at the MTC. However, there are some special considerations for an unexpected admission or deterioration in an existing patient who presents to a TU and requires neurosurgical assessment/management.

Key principles

Contacts and Pathway

Call network MTC: TU to MTC Emergency Department Time Critical Trauma transfers are automatically accepted and calls to MTC can be made after transfer initiated

(*In NELETN these patients should also have a "Referapatient" completed – this can also be sent AFTER the patient has been sent. The aim being to minimise the time spent in the TU ED. For non-critical transfers the patient should have a" Referapatient" sent first and then discussed with the MTC Consultant / Neuro Surgical team on call before the patient in sent*).

Alert ambulance services of a time critical transfer

For **Time Critical** patients arrange a local transfer. The most senior airway trained person available should do the transfer. A trained assistant should accompany the airway doctor [16,17]

Intubation should be carried out by most senior anaesthetist available[16,]

Discuss local access to scanning versus delay in transfer to MTC, with MTC ED Consultant

CT scan at TU if performed will require Image Transfer to MTC immediately and needs to be accompanied by a report

Transfer should not be delayed for arterial line monitoring or central venous access – obtain when able

Inotropes if required can be run peripherally. Note recent agreement from the paediatric transfer services for peripheral adrenaline as first line over dopamine[15]

Ensure neuroprotective measures throughout transfer

Be aware that cerebral perfusion pressure is dependent on mean arterial pressure minus intracranial pressure (CPP = MAP - ICP). Permissive hypotension is not acceptable. Maintain mean arterial pressure (MAP) to target an estimated minimum cerebral perfusion pressure (CPP) assuming that ICP is raised. Target CPP's:

Newborn 30-40mmHg

Child 50-60mmHg

Adolescents 60-70mmHg

Contact CATS (North Thames transfer service) or STRS (South Thames transfer service) if a non-time critical transfer is required

CATS / STRS TRANSFER SERVICES LINKS:

http://site.cats.nhs.uk/health-professionals/referrals

https://www.evelinalondon.nhs.uk/our-services/hospital/south-thames-retrieval-service/referrals.aspx

3.2. THORACIC TRAUMA

3.2.1 THORACIC TRAUMA at the MTC

Key Principles

Chest injury in infants and children ranges from trivial to immediately life threatening. Assessment, imaging and management should be proportional to injury:

Children have a flexible rib cage therefore significant injury can occur without rib fractures. Significant mechanism of injury should prompt suspicion of chest injury in children.

Ensure adequate analgesia to aid spontaneous ventilation.

If significant chest injury is suspected a CXR should be performed during the primary survey.

If CXR shows significant injury proceed with a CT chest [10]

In traumatic cardiac arrest, manage CA-B-C simultaneously

A thoracostomy may have been performed in the pre-hospital environment. This will require formal intercostal drain in hospital

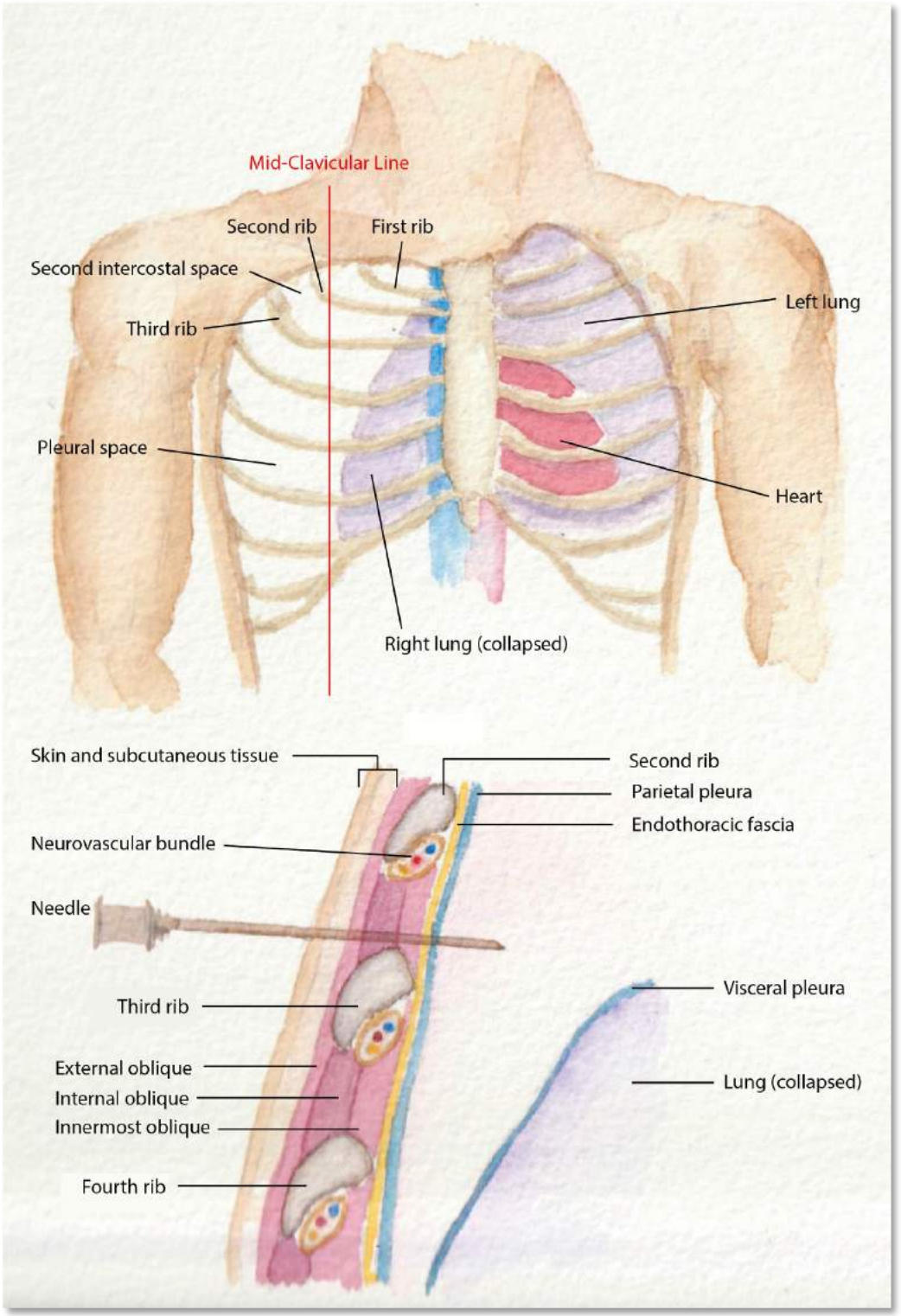
Significant pneumothorax and/or haemothorax at primary survey should be managed with intercostal chest drain, inserted under sedation or anaesthesia.

When intubating a patient with a potential chest injury team should be prepped and ready to perform thoracostomy should a tension pneumothorax occur, secondary to positive pressure ventilation

Needle decompression for tension pneumothorax can be performed in the 2nd intercostal space mid clavicular line or 5th intercostal space mid to anterior axillary line in younger children. Thorocostomy can be performed following decompression

4 x uncuffed ETT size is a guide to a good chest drain tube size in children (French gauge)

Image 2: Needle Decompression

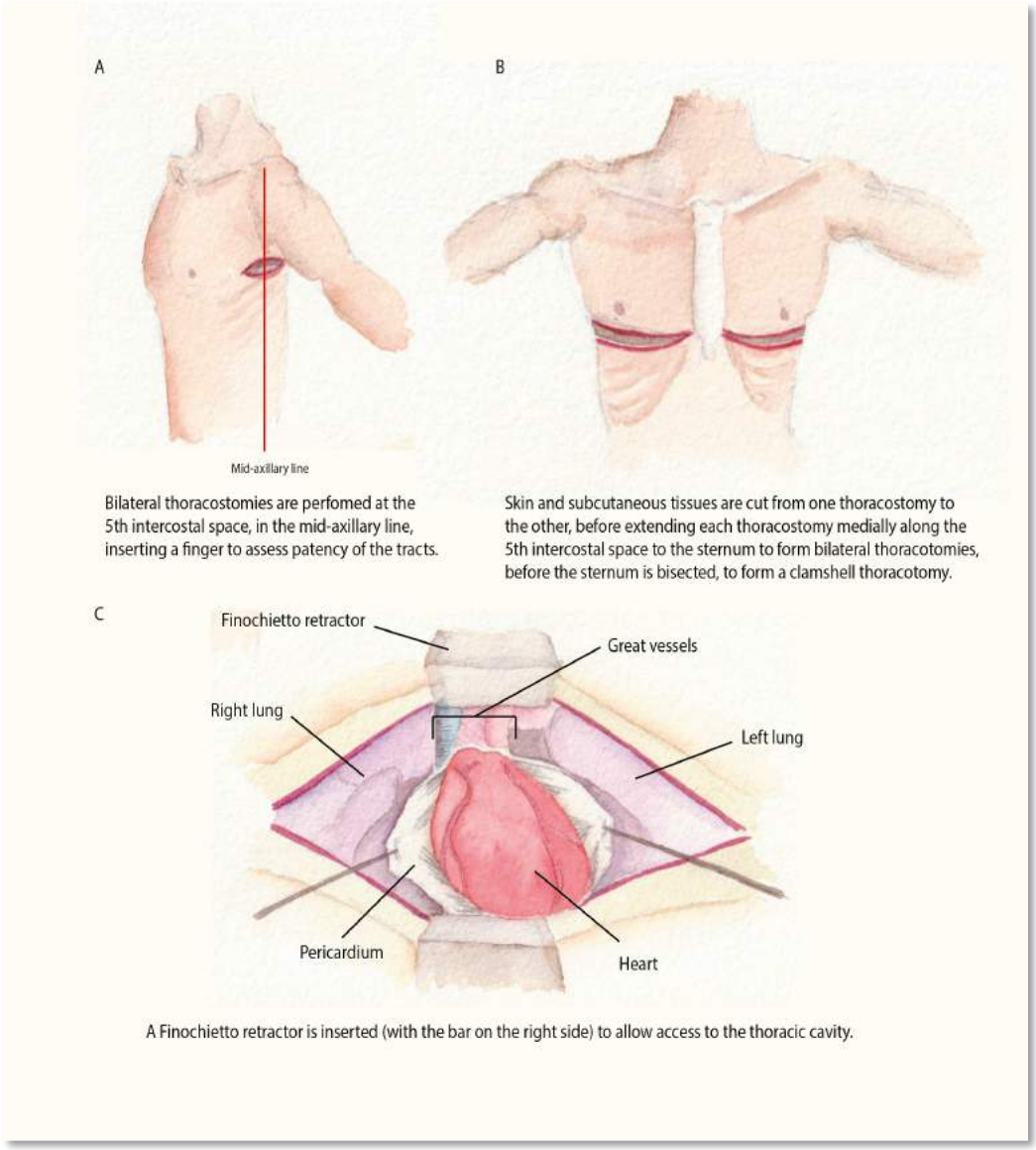


Thoracostomy: is a small incision into the chest wall. The opening is maintained for drainage and is most commonly used for the treatment of a traumatic pneumothorax.

If the patient deteriorates a gloved finger should be inserted through the thoracostomy and a finger sweep performed to ensure patency and that the lung is up. This excludes tension pneumothorax as a cause of deterioration. A definitive chest drain can be inserted following this.

Thoracotomy: surgical opening of the chest wall. This is indicated in penetrating injury and massive haemorrhage and/or pulseless electrical activity.

Image 3: Thorocostomy/Thoracotomy



3.2.2 Management of chest Injury (Thoracotomy)

Trauma call and pre-alert

Contact the on-call Consultant for Trauma/Cardiac Surgery, ED, Paediatric Anaesthesia and Theatre coordinator

Ensure an appropriately sized thoracotomy kit is available if required

A thoracotomy should only be performed in ED if the patient arrests in ED or is peri-arrest

This decision will need to be made by the trauma team leader in conjunction with the most senior clinicians present

Give generous haemostatic resuscitation prior to thoracotomy. Healthy paediatric cardiovascular systems are very responsive to filling

At induction of anaesthesia anticipate cardiovascular decompensation

Ideally anaesthetise in theatre on table with the surgeon scrubbed and the patient prepped

A cardiac style anaesthetic is advised (high dose opiate, lower dose of induction agent and muscle relaxant)

Have inotropic drugs/vasopressors ready and available

Do not delay the onset of lifesaving surgery to perform lines (but if large bore trauma line access is not available discuss with the lead surgeon who may want to cannulate the right atrium for access)

Transfer patient to theatre as soon as possible if thoracotomy is performed in ED. Resuscitation should continue there if required

Ensure internal defibrillator paddles are available for open chest procedures

3.2.3 Traumatic Cardiac Arrest (TCA)

The Delphi Study Consensus statement on Paediatric Traumatic Cardiac Arrest monitoring is outlined in the table below:[15]

Table 2: Paediatric Traumatic Cardiac Arrest Monitoring

Concept/definition of paediatric TCA
Blunt and penetrating trauma should be treated *differently*‡
Absent palpable pulses or no signs of life should trigger a paediatric TCA algorithm
The absence of cardiac activity on ultrasound should trigger a paediatric TCA algorithm
Process
Whole blood therapy improves survival
Warmed blood/fluids improves survival
Rapid volume replacement improves survival
Thoracotomy in penetrating trauma improves survival
Pericardiocentesis should *not* be performed in paediatric TCA‡
Ensuring oxygenation (via an endotracheal tube or supraglottic device) improves survival
Providing ventilatory support improves survival.
Decision to stop
Duration of arrest in paediatric TCA is helpful in determining the futility of continued resuscitation
The lack of response to any intervention is helpful in determining the futility of continued resuscitation
If all invasive procedures have been completed and there is no ROSC, this is helpful in determining the futility of continued resuscitation
Cardiac standstill on ultrasound is helpful in determining the futility of continued resuscitation, in the presence of appropriate resources and a trained operator

Key Principles

If there is a likely medical cause, continue ALS algorithm

In Traumatic Arrest, manage C-A-B-C simultaneously giving attention to

Hypoxia: give100% Oxygen, perform airway management

Hypovolaemia: control external haemorrhage and consider pelvic binder, splinting of fractures and use of tourniquets

Provide haemostatic resuscitation ensure large bore IV access (or IO if unsuccessful)

Reduce or stop sedation

Tension pneumothorax: perform bilateral thoracostomies

Tamponade (cardiac): consider thoracotomy after adequate filling in penetrating trauma. Thoracotomy in blunt injury is controversial as the evidence does not support its effectiveness.

No consensus was reached regarding adrenaline use. ALS protocol states;

Adrenaline dose (every other cycle) 0.1ml/kg of 1:10,000

Amiodarone (after 3rd shock) 5mg/kg

3.3 ABDOMINAL TRAUMA

3.3.1: Penetrating

Penetrating trauma including abdominal trauma is on the increase in children and adolescents. Penetrating abdominal wounds, (with the exception of superficial wounds), in patients who are haemodynamically normal, may undergo CT imaging with the trauma team present

Regular clinical evaluation is advised even if CT is normal

Keep a low index of suspicion for cardiac/thoracic injury in penetrating abdominal trauma. Diaphragmatic injury should be excluded

Do not remove the penetrating object in ED

3.3.2: Blunt

Children are more vulnerable than adults to blunt abdominal trauma due to their unique anatomy. They have relatively compact torsos with smaller anterior-posterior diameters. This provides a smaller area over which the force of the injury can be dissipated. They also have larger viscera; their liver and spleens extend below the costal margin making these organs vulnerable. In addition, they often have less overlying fat to cushion intra-abdominal structures from blunt force

Key Principles

Abdominal Injuries may be to the solid (liver, spleen, kidneys) or hollow organs (bowel, bladder) or may involve the great vessels

Free fluid within the peritoneum in the absence of identified injury should raise suspicion of covert injury and be closely observed

The majority of abdominal trauma in children may be safely managed conservatively. Liver, spleen and kidney injuries in children rarely require operative intervention

Increasingly interventional radiology and emoblisation can be employed if evidence of active bleeding in a child who is not haemodynamically unstable

Children with a history of significant trauma or high impact trauma should be admitted for observation even in the absence of examination findings
In the severely injured child, damage-control surgery and resuscitation should be implemented to decontaminate, control bleeding and resuscitate
In the event of considerable liver and pancreatic trauma advice can be sought for ongoing management via specialist liver centre. This should not delay resuscitation in the haemodynamically unstable child
Injuries identified in the chest and abdomen should raise suspicion of a diaphragmatic injury
Solid organ injury is classified based on the American Association of Trauma Surgeons (AAST) classification
Pelvic splints should be applied when there is a significant mechanism of injury
Plain films for pelvic injury are not routine in pre-teens but should be performed where the mechanism and/or assessment suggest possible injury
Movement should be minimised at all times through use of scoops and limited log rolling, to prevent disruption of clot

Investigations

Bloods, Blood Gas, FBC, U&E, LFT's, Lipase/Amylase & Clotting, Crossmatch, Blood Sugar.
Urine analysis: Urine analysis should be done on all abdominal trauma patients

Indications for laparotomy

Evisceration or omental herniation
Cardiac instability with penetrating or blunt wound
Uncontrollable haemodynamic instability with solid organ injury
Presence of abnormal CT such as free air, free fluid, solid organ injury
Development of peritonitis post injury
If operative management is required, interventional radiological procedures should be considered. However, this should not be at the expense of damage control principles

Indications for CT – see Radiology section (3.3.6)

3.3.3: Splenic Injury

Splenic injury is the most commonly injured solid organ in children

Where possible the aim is to avoid splenectomy due to risk of overwhelming post-splenectomy sepsis (OPSI), which has a high mortality rate

Non-operative management is possible for the majority of splenic injuries in children. It is the mainstay of treatment, even in high-grade injuries. Patients should be managed in the safety of a paediatric intensive care or specialized paediatric trauma ward within a major trauma centre

Patients managed non-operatively require repeated serial clinical observation. Duration of bed rest may vary from centre to centre

The risk is greatest in younger children.

Children form antibodies against encapsulated organisms late on. Encapsulated organisms are ineffectively protected against in hyposplenic patients.

Common organisms include:

- *Strep. pneumoniae* (>50%),
- *Neisseria meningitides*,
- *Haemophilus influenza*
- *Strep. pyogens*.

Risk of overwhelming post-splenectomy infection (OPSI) is greatest in the two years following splenectomy but can occur at any time. A vaccination schedule should include cover for the commonly implicated microorganisms. In emergency splenectomy patients, a better antibody response occurs if vaccination is delayed for 14 days after surgery to minimize the immunosuppressive impact of surgery.[21]

3.3.4: Liver Injury

Liver injury can be managed nonoperatively in > 80% of cases.[25]

Nonoperative management requires that the child has an age-appropriate normal haemodynamic profile and is monitored closely for evidence of on-going bleeding.

The AAST liver injury scale, most recently revised in 2018, is the most widely used liver injury grading system
The 2018 update incorporates "vascular injury" (pseudoaneurysm, AV fistula) into the imaging criteria for visceral injury
Children with higher grade injuries may benefit from intensive care unit observation [25,26]
Contrast enhanced ultrasound should be considered for follow up of injuries
In the child who is in extremis, damage-control procedures are required, with the goal of bleeding control via packing and resuscitation
Consider discussion with regional liver centre within 48hrs in high-grade pancreatic trauma

3.3.5 Bladder / Renal Injury

Visible haematuria in the setting of abdominal trauma should be investigated with CT (CT abdomen and pelvis with delayed phase) to assess for renal or renal tract injury
The bladder is an intra-abdominal organ in children and is susceptible to injury, particularly in association with pelvic fractures. Pelvic fractures may also cause urethral injury. If there is concern regarding complex pelvic injury or urinary tract injury, a delayed phase abdominal and pelvic CT with contrast is required for assessment with an ascending contrast urethrogram
Blood at the meatus is a classic sign of urethral trauma in boys. Further injury can be caused by inappropriate attempts at urethral catheterisation so if there is evidence of injury, the child should be referred to a paediatric urologist
If bladder drainage is needed prior to transfer, a suprapubic catheter should be inserted under general anaesthetic with ultrasound guidance. The bladder anatomy can be seriously distorted by pelvic fractures and extraperitoneal haematoma

3.3.6 Interventional Radiology

Consider Interventional Radiology for active abdominal bleeding such as in splenic or liver injury (as demonstrated by contrast blush on CT), in those who are not haemodynamically unstable.

IR is now a well established management pathway for adult trauma patients, with its use in paediatric trauma increasing.

Advances in neurovascular and endovascular techniques have meant equipment and experience working in smaller vessels has improved greatly over recent years, making IR an increasing option for children.

Indications for IR

Ongoing clinical suspicion of haemorrhage in presence of injury, as evidenced by active contrast extravasation on CT

Persistent tachycardia despite pain relief

Falling Hb or haematocrit in context of the above

On-going requirement for blood/blood products +/- need for vasopressor/inotropic support, within context of solid organ injury

Not meeting criteria for emergency laparotomy

Successful embolisation used in liver, splenic and pelvic trauma, reduces the risk of re-bleeding, but is not classified as definitive management. Embolisation may be carried out with either coils, which aim to reduce the perfusion pressure within the vessel, or gelfoam slurries which occlude the vessel.

Potential complications include:

Infarction

Abscess formation (solid organ)

Failure to achieve haemostasis

Re-bleeding

Benefits of endovascular approach:
In solid organ injury it is an opportunity to salvage organs and preserve immune function
Endovascular intervention can be an additional technique to increase the yield of non-operative management (NOM) when conservative management fails
Evidence, although limited, seems to suggest safe approach with reduced morbidity
Avoidance of surgical procedure and its sequelae with reduced potential for worsening hypothermia and coagulopathy

Where possible embolisation should be discussed as it reduces the morbidity of operative intervention. Departments may vary in terms of availability and willingness to intervene in children however this still merits discussion. There is little evidence for interventional procedures in those younger than adolescents however the small number of cases which have been performed have been documented with success.

The trauma team should always travel with the child to IR, if going directly from ED. It is of vital importance that theatre teams are available to intervene in the IR suite; deterioration is most frequently associated with massive haemorrhage. Teams should be experienced with working outside of the operating theatre environment to facilitate safe management and transfer of the patient. This can be achieved through clearly defined pathways of management and simulation.

3.4. PELVIC TRAUMA

Key Considerations

Pelvic fractures in children are uncommon and haemorrhage in association with pelvic injury is very rare

Pelvic splinting should only be applied when there is a mechanism of injury and clinical assessment consistent with potential for serious injury and associated bleeding

Ensure application of a pelvic binder for patients with history of blunt trauma and associated tachycardia/hypotension

Plain films for pelvic injury are not routine in pre-teens but should be performed where the mechanism suggests possible injury

Protocols should be in place for emergency interventional radiology in serious pelvic injury and associated major haemorrhage

The "1st clot is the best clot". With this is mind, do NOT spring the pelvis. Keep the pelvic binder on until injury is excluded. Avoid repeated logrolling. If required minimize movement to 15 - 30 degree tilt.

3.4.1 Management of Suspected Pelvic Injury

The binder should be placed at the level of the greater trochanters, not the iliac crests.

Obtain an early pelvic x-ray (or immediate CT) to clear the pelvis if the mechanism is significant or primary survey suggests injury.

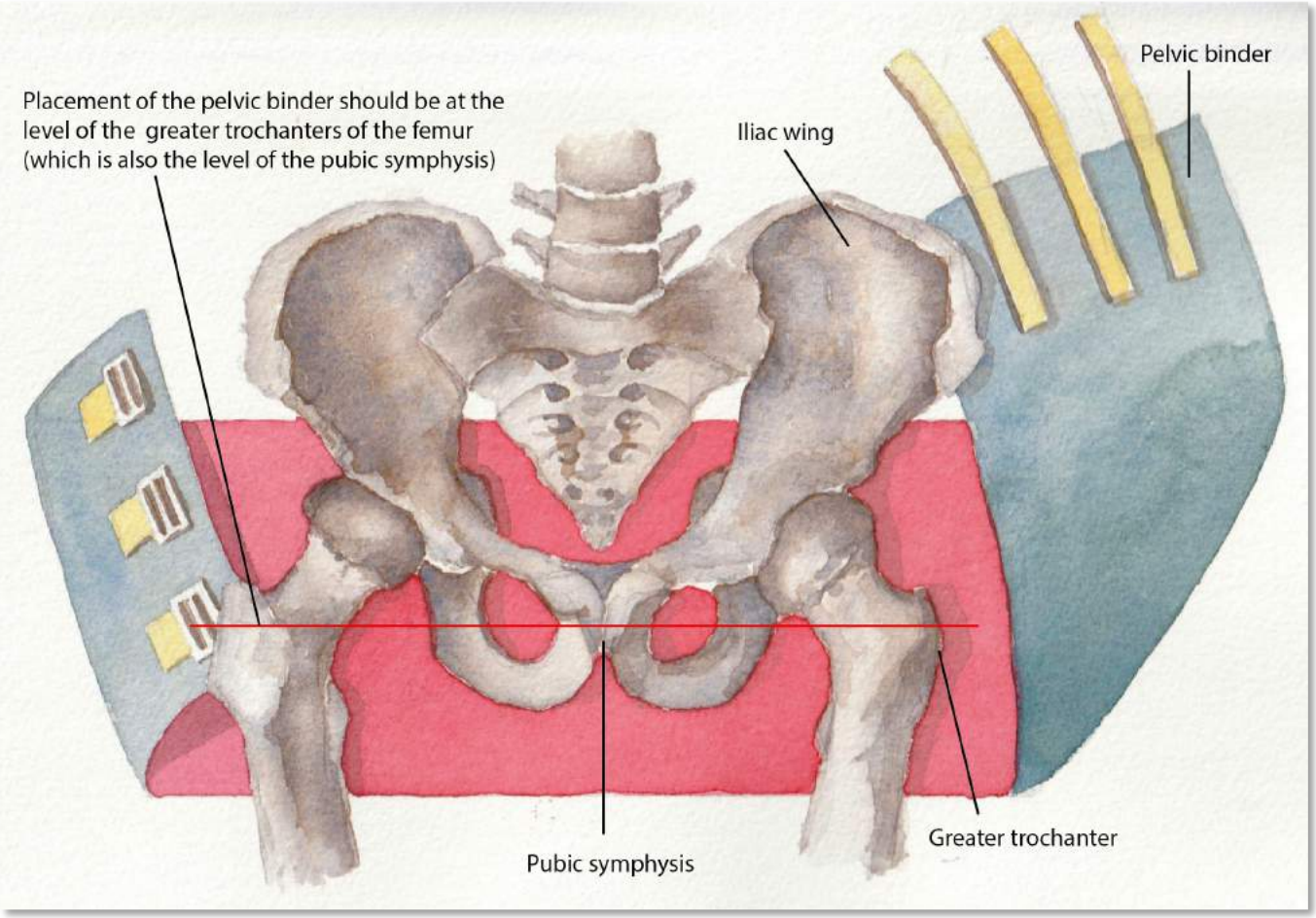
Do NOT examine/spring the pelvis for mechanical stability.

Do NOT logroll the patient until the pelvis is cleared.

Minimise movement at all times to prevent disruption of clot

Consider pelvic fractures in persistently tachycardic patients with a significant mechanism of injury.

Image 4: Principles in Management of Pelvic Fractures



Pelvic Binders splint the pelvis to provide tamponade and prevent movement of any fracture points

Pelvic binder can remain in place for up to 24 hours

Differentiate early between pelvic and intra-abdominal bleeding

Consider interventional radiology if bleeding is suspected and prepare team/ equipment

Where pelvic trauma with associated haemorrhage requires an interventional procedure, the trauma team should remain with the patient until there is haemodynamic stability.

Senior surgical assistance should be present and involved in all decision making.

If the binder needs to be removed for cannulation access in interventional radiology suite, anticipate cardiovascular instability. Ensure slow release of binder and be prepared to deliver haemostatic resuscitation.

With any pelvic fracture, examine carefully for open wounds, especially around the perineum/rectum. If there is an open wound, including vaginal lacerations, antibiotics must be administered as per local guidelines.

PR examination should be performed in association with significant pelvic fracture

In male patients with pelvic fractures and either blood at the meatus or any history of haematuria, consider a retrograde urethrogram particularly following difficult catheterisation

If active bleeding is identified on CT (as demonstrated by contrast blush) embolization of pelvic or iliac vessels may be required. It is rare for a child to require pelvic packing, however if unstable the principles of damage control surgery apply

Senior team leaders should consider pelvic packing/laparotomy/REBOA and/or clamping of the abdominal aorta if bleeding remains uncontrolled

3.5. MAJOR HAEMORRHAGE

Major haemorrhage can be defined as severe, ongoing, often non compressible bleeding, requiring immediate blood product resuscitation. This may be accompanied by signs of shock or acute coagulopathy. Children have excellent compensatory mechanisms so clinical signs of shock may present late.

Key Principles:

Requires senior decision making early in the pathway

Bleeding sites may include the chest, abdomen, pelvis, long bones or indeed head and scalp in traumatic brain injury

Retroperitoneal Bleeding may be concealed and therefore difficult to identify without imaging

Remember one site is not necessarily the only site

Consider A-B-C-D-E or C-A-B-C-D-E

Assess/Reassess with early options for IV access, bloods and cross match

Trauma team to remain with patient where there is ongoing resuscitation

3.5.1: Blood Samples

FBC, U&E, Coagulation, Fibrinogen, Cross Match x 2 and consider ROTEM/TEG if available

3.5.2: Principles of Management

Avoid Hypothermia: aim for normothermia, ensure warmed products, forced air warmers, environmental temperature control

Avoid Acidosis: permissive hypotensive resuscitation may have values on boundary of normal

Balanced product administration as per major haemorrhage protocol

Although there is potential for volume overload in children this should not hinder resuscitation in massive haemorrhage

Correct Electrolytes with particular attention to maintaining Calcium and managing hyperkalemia

Ensure easy access to local paediatric Major Haemorrhage protocols

Document timings of pelvic binder and/or tourniquets
Pressure on bleeding points with application of splints in fractures
Managing major haemorrhage in children is a rarer event; consider human factors and practice via simulation

Theatre set up/equipment:

Warm environment
Theatre table in crucifix layout +/ arm-boards depending on age
Ensure rapid infuser device & availability of blood products
Identify team leader in theatre and roles of supporting team, including communication with blood transfusion and dedicated runner
Supportive equipment such as major haemorrhage trolley with all required access, chest drains
Brief handover on arrival of patient to ensure all staff equally well informed
Trauma WHO checklist

3.5.3 Products

O negative blood in extreme emergency
Cross matched blood if time available (40 minutes on average), or subsequently if ongoing haemorrhage
Ensure Tranexamic acid (TXA) 15mg/kg (max 1g) has been administered, ideally within the first hour post injury
Transfuse 10-20mls/kg of PRBC (give in 5ml/kg boluses)

If ongoing bleeding:

FFP 10ml-20mls/kg in 5ml/kg aliquots (Octaplas if available)
Cryoprecipitate 10mls/kg
Give platelets after every 30/ml/kg of PRBC
Consider 2mg/kg/hr TXA until bleeding controlled.[18.] Although not necessarily included in all paediatric major haemorrhage protocols, this is utilised in complex paediatric neuro, spinal and cardiac surgery

3.5.4 Constant Reassessment and Correction:

Hypothermia

Acidosis

Hypocalcaemia: if ionised calcium on blood gas (Ca2+) < 1.0 give 0.2mls/kg to a maximum of 10mls of 10% calcium chloride. Then reassess.

Hyperkalaemia. K+ > 6-7

Treat Hyperkalaemia if:

If K+ is 6-7mmol/l and patient is symptomatic with cardiac conduction abnormalities,

tall T waves

prolonged PR interval

decreased or disappearing P wave

widening QRS complex

amplified R wave

bundle branch block

or

if the patient is at risk of a further rise in potassium level (ongoing resuscitation, crush injury)

If K+ ≥7 mmol/l and asymptomatic

Treatment of Hyperkalaemia

Calcium Gluconate: (10% solution)

IV 0.5ml/kg over 5 minutes (max dose 20ml = 2g)

Insulin:

0.1unit/kg in dextrose (glucose) infused at 0.05-0.1units/kg/hr, with ongoing glucose monitoring.

Regarding **dextrose** solution, *give 10% dextrose (100 mg/mL) at a dose of 5 mL/kg/hr.*

Consider **bicarbonate**

1 to 2 mmol/kg/dose over 30 minutes.[1]

Nebulised **salbutamol**

2.5mg (if < 25kg) 5mg (if >25kg)

For persistent hyperkalaemia consider filtration (CVVH)

AIMS / Lab tests

FFP/Octaplas if PT or APTT >1.5 x normal

Cryoprecipitate if Fibrinogen < 1.5g/l

If ongoing bleeding maintain HB >100g/l

Platelets with aim >100 (10^9 per litre)

Point of Care Testing (ROTEM/TEG)

Thromboelastography (**TEG**) and rotational thromboelastometry (**ROTEM**) are point of care tests which can be used to diagnose individual components contributing to bleeding/coagulopathy, allowing quick assessment of contributing factors and tailored product resuscitation.

ROTEM VALUES * follow local protocols (sample in appendix)

See BJA references below - ranges by age https://academic.oup.com/view-large/4383568

ROTEM > 50Kg protocol example (see appendix)

3.5.6 Major Haemorrhage Policy: A guide to bolus volumes for resuscitation

Red Cells	FFP / Octaplas	Platelets *	Cryoprecipitate
10-20mls/kg	10-20mls/kg	15mls/kg	5-10mls/kg

When approaching adult weight (approximately 30kg) consider using adult volumes / policy.

* Discuss Volume requirements with transfusion/follow local Major Haemorrhage protocols

3.5.7 Blood Refusal

A child is defined as anyone under the age of 18
Children aged 16 to 17 years have a legal right to consent to their own treatment, even if it is against the wishes of their parents (as do younger children who are deemed to be Fraser (formally known as "Gillick") competent (England and Wales)
A child under the age of 18 does not have the legal right to refuse treatment and lawful consent to life saving procedures can be given by the parents or by the courts
If transfusion is essential to save life or prevent serious permanent harm, blood should be given without waiting for a court order. In these circumstances, two consultants should make a written entry into the patient's notes that. Trust solicitors should be contacted simultaneously in order to obtain a court order

3.6. EXTREMITY TRAUMA

3.6.1: Factors for Consideration in Paediatric Trauma

Children with orthopaedic injuries should have shared paediatric care for ongoing medical and safeguarding needs

Child safeguarding concerns should be considered in all cases

Limb and soft tissue injuries are common in children

Open fractures are less common

Supracondylar fracture of the humerus is the most common injury associated with neurovascular compromise in children. The "pink but pulseless upper limb" in this context should undergo emergency reduction under appropriate procedural analgesia/sedation or general anaesthesia in theatre

Advice should be sought early if vascular support is required

Similar urgency should be applied with neurovascular compromise of any traumatic limb injury

Femoral fractures are relatively common in childhood following serious mechanisms of injury. This fracture can occur in association with serious head injury

Femoral nerve block should be considered as a standard of care in all age groups as a component of early analgesia provision [6]

BOAST guideline for open fractures should be followed [6,7,8]

BOAST Guidelines include:

Recommendations for IV antibiotics within one hour

Advice on alignment and splinting of limb

Assessment of the injured limb and documentation of vascular and neurological status, particularly after reduction or application of splints

Management of open areas which should be photographed, soaked with a saline-soaked gauze and covered with an occlusive dressing.

Ongoing monitoring of the limb for compartment syndrome.

3.6.2: Time frame for management of open fractures [6,7,8]

Immediate
Highly contaminated wounds (agriculture, aquatic, sewage) Vascular compromise/compartment syndrome or arterial disruption with ischaemia
Within 12 hours
Solitary high energy open fractures
Within 24 hours
Low energy open fractures

Management of Arterial Injuries Associated with Fractures and Dislocations

Resuscitation and management of all life threatening injuries must take priority over any extremity problems.

Fast diagnosis is of paramount importance for successful limb salvage.

Active extremity haemorrhage must be controlled immediately by direct pressure and/or tourniquet. Blind clamping in wounds is discouraged and potentially damaging.

Neurovascular injury should be assumed in all injured extremities.

The findings of neurovascular examination must be documented.

Examine for altered sensation and expanding haematoma (limb threatening) and pulses.

The "pink, pulseless" limb must be assumed to have an arterial injury until proven otherwise.

The pulseless, deformed limb should be re-aligned, and any dislocations reduced under appropriate sedation or anaesthesia. In many cases, the circulation will be restored

The limb should be splinted, and the neurovascular examination repeated and documented

Appropriate radiological imaging should be obtained

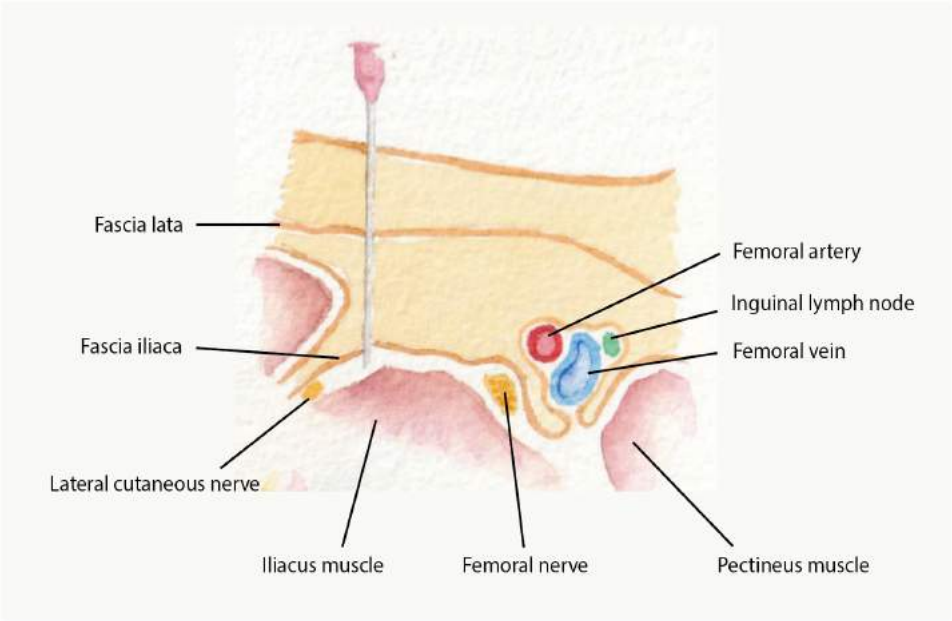
There should be immediate referral to a surgeon with the skills to perform vascular repair at the time of diagnosis and a low threshold for early surgical

intervention. All Trauma Units and Major Trauma Centres must have a clear emergency referral protocol to the appropriate vascular surgical team (plastic, vascular, general, or hand surgery)
The responsibility for managing these cases lies jointly with the orthopaedic surgeon and the team managing the vascular injury
A devascularised limb requires urgent surgical exploration
A decision to perform early amputation should be made by two consultants
Beyond 3-4 hours, warm ischaemia results in irreversible tissue damage and an increasing risk of amputation
Imaging modalities include duplex, angiography, CT angiogram and on-table angiogram. Access to these must not significantly delay reperfusion/surgery
Peripheral nerve injury identified at the time of surgery should be carefully documented and the patient referred early to the appropriate specialist. If the expertise is available, ideally peripheral nerves should be repaired
The risk of compartment syndrome is high following reperfusion and there should be a low threshold for performing fasciotomies
Post-operative care should be provided in an appropriate area with nursing and medical staff competent in the assessment of the critically injured limb[48]

3.6.3 Fascia Iliaca Block

Femoral fractures and associated traction are associated with pain.
Nerve blocks can in addition to other modes of analgesia provide effective safe analgesia, minimise opiate requirements and provide pain relief until surgical fixation.
Before proceeding to peripheral nerve blockade, routine safety checks must be adhered to. "Stop Before You Block"[44]
Patients receiving a block should be managed using AAGBI guidelines

IMAGE 5: Fascia Iliaca Block / Distribution of sensory block



This block is a High Volume BLUNT NEEDLE BLOCK. Suggested volumes are highlighted below. Dilute local anaesthetic concentrations with 0.9% NaCl to achieve near suggested volumes.

Local Anaesthetics Commonly Used

Levobupivacaine MAX DOSE 2mg/kg

Ropivacaine 3mg/kg

Ensure adequate volumes given (see below).

Weight	2-10kg	15kg	20kg	25kg	30kg	40kg	50kg	60kg>
Volume	1ml/kg	12.5ml	15ml	17.5ml	20ml	22.5ml	25ml	30ml

Technique

Anaesthetise skin with local anaesthetic cream or subcutaneous lignocaine1% prior to blunt needle insertion. Consider nitrous oxide or IN/IV fentanyl to facilitate patient positioning which may be painful.

Prep site with chlorhexidine

Using Sterile gloves, locate the femoral crease ASIS to pubic symphysis

Image 6: Surface Landmarks

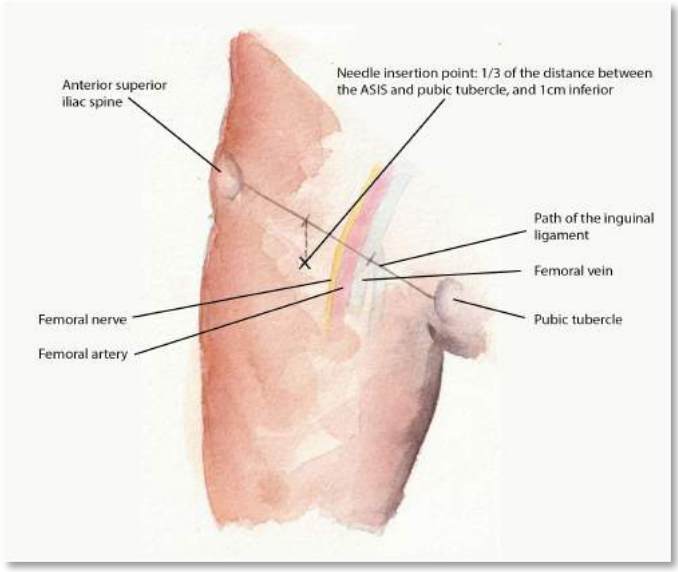
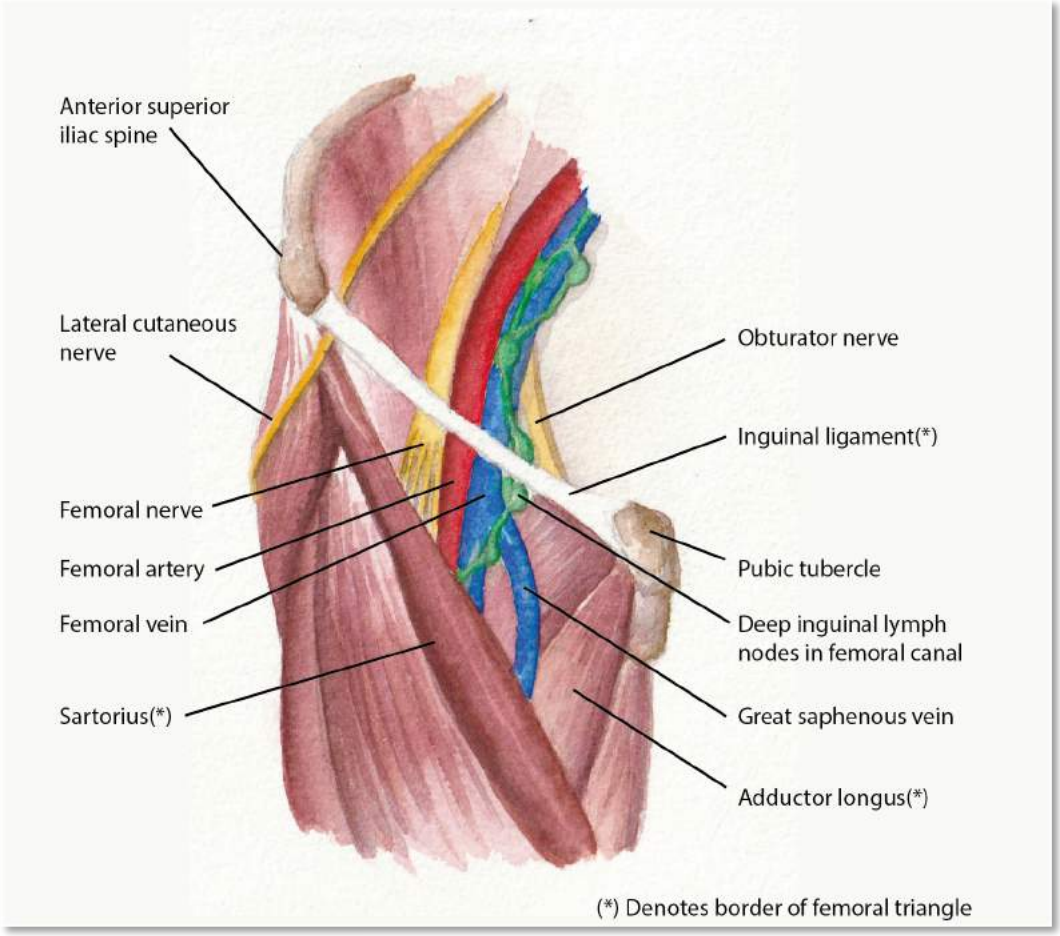


Image 7: Internal structures



Note Anatomy - Medial - **Vein Artery Nerve** *– Lateral*

Palpate artery: insert lateral and inferior to artery

Pierce anaesthetised skin with blunt needle. Await double pop. Second pop denotes passage though fascial planes

Aspirate prior to injection to ensure not in a vessel.

Stop if resistance felt.

3.7. SPINAL TRAUMA

Trauma to the spine in young children can produce neural damage without bony injury. The paediatric spine is more elastic than that of adults and as a result more vulnerable to subluxation. The facet joints are shallow and more horizontal in children allowing a degree of slippage and this, in association with under-developed musculature, lends to a more flexible core. Understanding the developmental age of the child is essential when interpreting between pathological and normal images and very much the remit of specialist radiology.

Children below 8 years have a relatively large and heavy head compared to truncal mass, which shifts the momentum of movement to the upper cervical spine. In infants and young children, maximum movement occurs at C2/3, in older children (age 5–6 years) this shifts to C3/4 whilst in older children it shifts to C5/6 as in adults. The majority of spinal injuries occur between C1 and C3 in young children whereas older children, like adults are more likely to sustain injury further down the C spine.[31]

Key Facts

Cervical spine bony injury is uncommon in paediatric patients compared to adults.

Imaging of the cervical spine is not indicated on the basis of head injury alone: NICE has a separate algorithm extrapolated from adult data.

Plain films may be indicated and if performed should include:

Lateral c-spine from base of skull to C7/T1 junction

AP C-spine from C2-T1

Adequate peg views (may be difficult in younger children)

In the presence of neurological findings suggestive of cervical spine injury, MRI scan is the investigation of choice due to the risk of spinal cord injury without radiologic abnormality (SCIWORA).

3.7.1 C-spine immobilisation

The Royal College of Emergency Medicine (RCEM) recognises that in some trauma systems there has been a move away from the use of 'hard' cervical collars for immobilisation of the cervical spine and that such collars often do not fit children (particularly young children) well. [31]

Cervical immobilisation should be used in all children with a potential cervical spine injury until such an injury has been ruled out by appropriate clinical assessment and imaging (if indicated).

The 2016 NICE Guidance recognises that there are possible disadvantages to use of a hard collar such as increasing intra-cranial pressure through reduced venous drainage and the potential for pressure sores. However, the use of a properly fitting collar, applied by a competent individual, should still be considered an effective tool for the prevention of secondary spinal cord injury. It can be used when tolerated in addition to blocks/rolled blankets and tape though is not strictly mandated

Advanced Paediatric Life Support course favours manual in-line stabilisation (MILS) in conscious children +/- blocks and tape to facilitate comfort

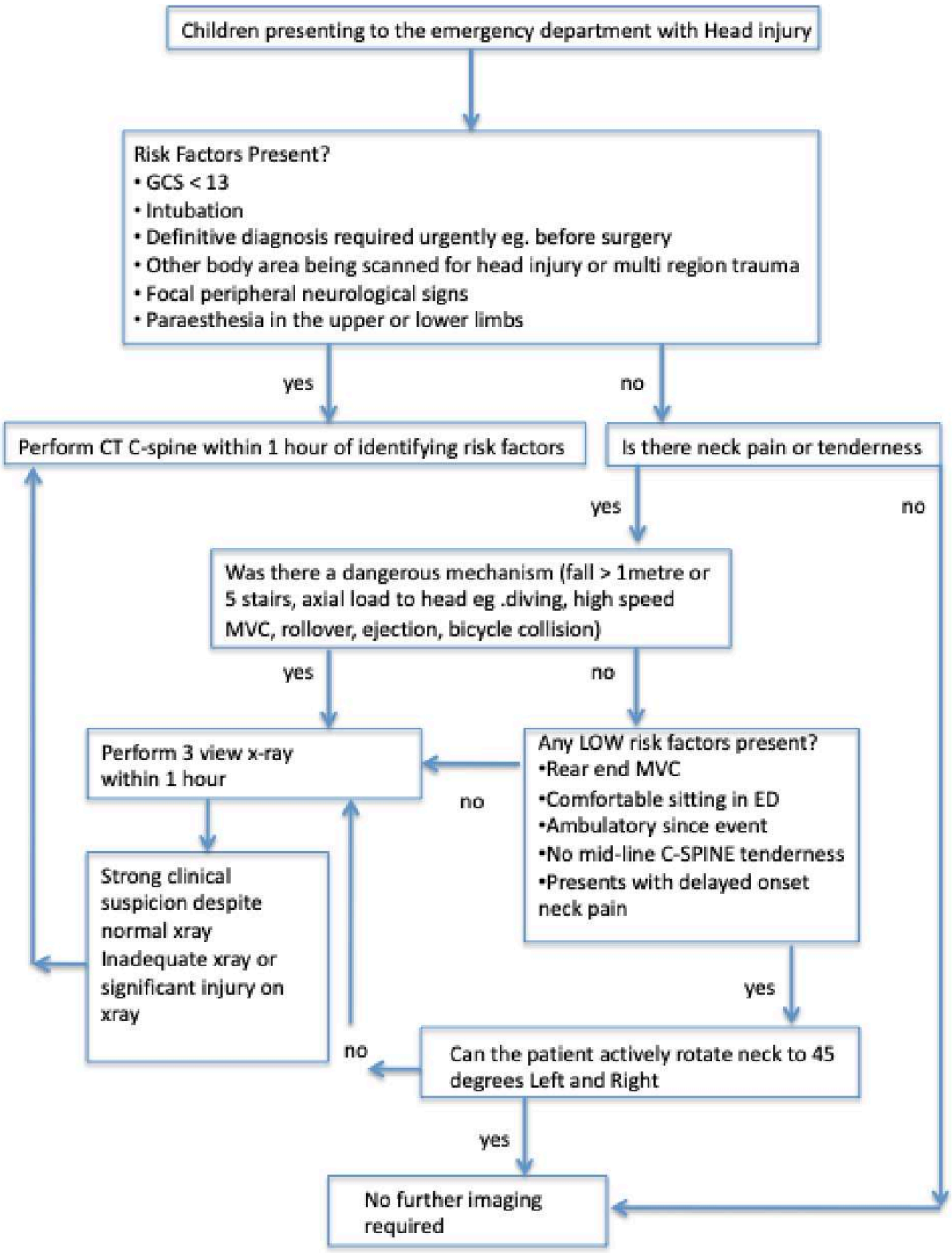
If attempts at immobilising the cervical spine are causing distress and agitation an assessment of the risks/benefits of continued attempts at immobilisation must be made

In unconscious children or when MILS cannot be maintained, immobilisation should be with a properly fitting collar, blocks and tape

Collars should be removed, and MILS maintained prior to intubation attempts

MILS should be maintained for intubation attempts if c-spine is not cleared

Selection of Children for Imaging of the Cervical Spine



National Institute for Health and Care Excellence. *CG 176 Head Injury: Triage, assessment, investigation and early management of head injury in children, young people and adults*. London: NICE, 2014. Reproduced.

3.7.2 Thoracic / Lumbosacral Spine

Assess the child for spinal injury, initially taking into account the following factors:

- any significant distracting injuries?
- under the influence of drugs or alcohol? (older children)
- confused or uncooperative?
- reduced level of consciousness?
- any spinal pain?
- any hand or foot weakness? (motor assessment)
- altered or absent sensation in the hands or feet? (sensory assessment)
- any priapism?
- any history of past spinal problems, including previous surgery or conditions that predispose to instability of the spine?

Carry out full in-line spinal immobilisation if any of the factors are present.

Assessment for thoracic or lumbosacral spine injury

Assess the person with suspected thoracic or lumbosacral spine injury using these questions:

Is there pain in the thoracic or lumbosacral spine?
Was there a dangerous mechanism of injury? (fall from a height, axial load to the head or base of the spine, high-speed motor vehicle collision, rollover motor accident, lap belt restraint only, ejection from a motor vehicle, accident involving motorised recreational vehicles, bicycle collision, horse riding accidents)
Does the child have pre-existing spinal pathology?
Is there a suspected spinal fracture in another region of the spine?

Are there abnormal neurological symptoms (paraesthesia or weakness or numbness) on examination?
Is there a new deformity or bony midline tenderness (on palpation), bony midline tenderness (on percussion) or midline or spinal pain (on coughing)?
For ambulatory patients is there pain on mobilisation (sit, stand, step, assess walking): pain or abnormal neurological symptoms (stop if this occurs)?
Be aware that assessing children with suspected thoracic or lumbosacral spinal injury is difficult and the child's developmental stage should be taken into account.
Perform MRI for children (under 16s) if there is a strong suspicion of:
cervical spinal cord injury as indicated by clinical assessment,
abnormal neurological signs or symptoms, or both.
Consider CT in adults (or children 16 or over).
If, after CT, there is a neurological abnormality, which could be attributable to spinal cord injury, perform MRI.

Suspected thoracic or lumbosacral column injury only[33]

Perform an X-ray as the first-line investigation for children with suspected spinal column injury without abnormal neurological signs or symptoms in the thoracic or lumbosacral regions (T1–L3)
Perform CT if the X-ray is abnormal or there are clinical signs or symptoms of a spinal column injury
If a new spinal column fracture is confirmed, image the rest of the spinal column
Use whole-body CT in children (16 or over) with blunt major trauma and suspected multiple injuries
Do not routinely use whole-body CT to image children (under 16s). Use clinical judgement to limit CT to the body areas where assessment is needed.

If spinal cord injury is suspected in children aged over 4 years, complete an ASIA chart (American Spinal Injury Association) as soon as possible in the emergency

department, and record: vital capacity for people over 7 years and ability to cough. [33]

BOA guidelines on spinal trauma in adults (attached link) is due for update 2020
https://www.boa.ac.uk/uploads/assets/89870cee-0ae7-4bf9-a081669550454e65/948c5c81-b37e-431e-8fbdf78ea33514a4/spinal%20clearance%20in%20the%20trauma%20patient.pdf

3.8. BURNS

Burn care is organised using a tiered model of care whereby the most severely injured are cared for in services recognised as "Specialist Burns Centres" and those requiring less intensive clinical support being cared for in a "Burns Unit."

3.8.1 London Referrals

Specialist Burns Centre/ICU

If injured child is > 6 months +/or > 6 kg, refer to St Andrew's Centre for Plastics Surgery and Burns (Broomfield Hospital). This includes intubated children
Contact: 01245 516037
If injured child is < 6 months +/- 6kg, referral will be to Birmingham, Bristol or Manchester.

Burns Units

Chelsea and Westminster Hospital
Queen Victoria Hospital East Grinstead

Link to London & South East Burns Network (LSEBN): http://www.lsebn.nhs.uk [9]
Transfers out of network may occur due to bed availability for burns. Be aware you may need to discuss with neighbouring networks.

3.8.2 Absolute Criteria for referral to a Paediatric Specialist Burns Centre

- Burn ≥ 30% TBSA
- Burn ≥ 20% TBSA Full thickness
- Burn ≥ 15% TBSA in < 1 year old
- Burn + inhalation injury or need to ventilate
- Burn + major trauma
- Burn + requirement for inotropic support
- Burn + requirement for renal support
- Burn + base deficit >6 and deteriorating
- Burn + O2 Requirement >FiO2 of 50%

3.8.3 Trauma Call: Important factors in the management of a patient who has sustained a burn injury

Note the history and mechanism:

Are there safeguarding concerns?

Was there an explosion?

Where was the patient found?

Was there exposure to fire and/or smoke?

Is there a risk of cyanide toxicity?

Consider other traumatic injuries

A: Consider intubation if signs of inhalational injury, circumferential neck injury or large airway burns. Leave endotracheal tube (ETT) uncut to allow for swelling over next 48 hours.

Cervical spine: immobilise if appropriate

B: Monitor carbon monoxide levels and consider cyanide poisoning, particularly if incident occurred in a confined space

C: Establish IV or IO access.

Parklands formula for fluid calculations-see below.

Insert urinary catheter. Ensure urine output 1ml/kg/hr and titrate fluids accordingly (0.5mls/kg/hr in teenagers/adults)as per ATLS guidelines.

ECG monitoring for all electrical burns.

Children [45]

3ml of Hartmann's Solution X weight in Kg X TBSA burned. 50% given in 1st 8 hours form time of injury, remaining 50% given over next 16hrs *

Adults/Teenagers:

2ml of Hartmann's Solution X weight in Kg X TBSA burned. 50% given in 1st 8 hours form time of injury, remaining 50% given over next 16hrs *

Note

There is a trend amongst specialist centers for a more restrictive fluid resuscitation guided by end organ perfusion and urine output.

For electrical injury the ALTS suggested requirement is higher 4mls of fluid x weight in kg x TBSA burn. [45]

D: Check blood sugar.

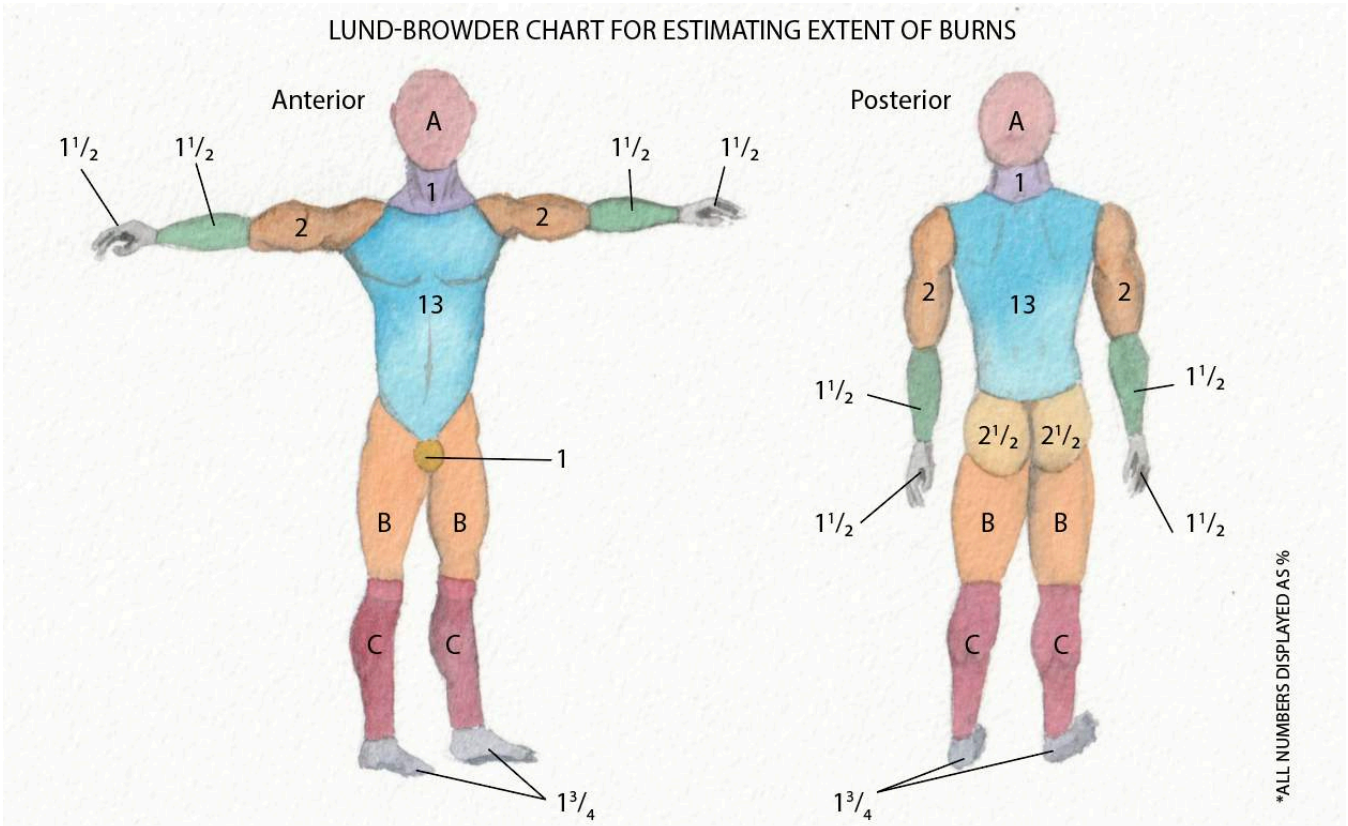
Beware evaporative heat loss and use forced air warmer such as bair hugger and administer warmed fluids. Keep environment warm.

Ensure adequate analgesia.

E: Calculate burns area using a Lund and Browder chart as illustrated below (NB: calculations include only dermal and full thickness burns. Exclude areas of simple erythema).

Photograph burns and upload images to http://trips.nhs.uk

Image 8: Lund-Browder chart for estimating burns



RELATIVE PERCENTAGE OF BODY SURFACE AREA AFFECTED BY GROWTH:	0 YEARS	1 YEAR	5 YEARS	10 YEARS	15 YEARS
A (1/2 OF HEAD)	9 ½%	8 ½%	6 ½%	5 ½%	4 ½%
B (HALF OF 1 THIGH)	2 ¾%	3 ¼%	4%	4 ¼%	4 ½%
C (HALF OF 1 LOWER LEG)	2 ½%	2 ½%	2 ¾%	3%	3 ¼%

The Mersey Burns app will calculate this automatically for you by filling in the area on the app.

https://merseyburns.com

3.9. RADIOLOGY

Children are not considered as small adults with respect to radiology. Injuries regarded as common and serious in the adult population such as spinal or pelvic injury are rare in pre-adolescent children whereas, injuries regarded as life-threatening in the adult population such as liver and splenic trauma are routinely managed conservatively in children.

The cancer risk of computed tomography (CT) in childhood is significant and is higher in younger ages. Careful clinical evaluation, judicious use of plain radiographs and targeted use of CT is recommended to guide decision making regarding radiation risk versus risk of missed injuries.

Principles of Management in Paediatrics

Children require competent clinical evaluation by clinicians who are familiar with injury at different stages of development (RCR)
Clinicians should consider judicious use of plain radiographs with targeted CT scanning following relevant paediatric protocols (RCR)
Exposure to ionising radiation should always be kept to a minimum and "as low as is reasonably achievable" (ALARA) (RCR)
Although "lifetime cumulative exposure" is a consideration it should not prevent appropriate and timely investigations
https://www.rcr.ac.uk/publication/paediatric-trauma-protocols (diagram *approved for use by the RCR and Dr Robert James, reproduced by Matthew Heron)*

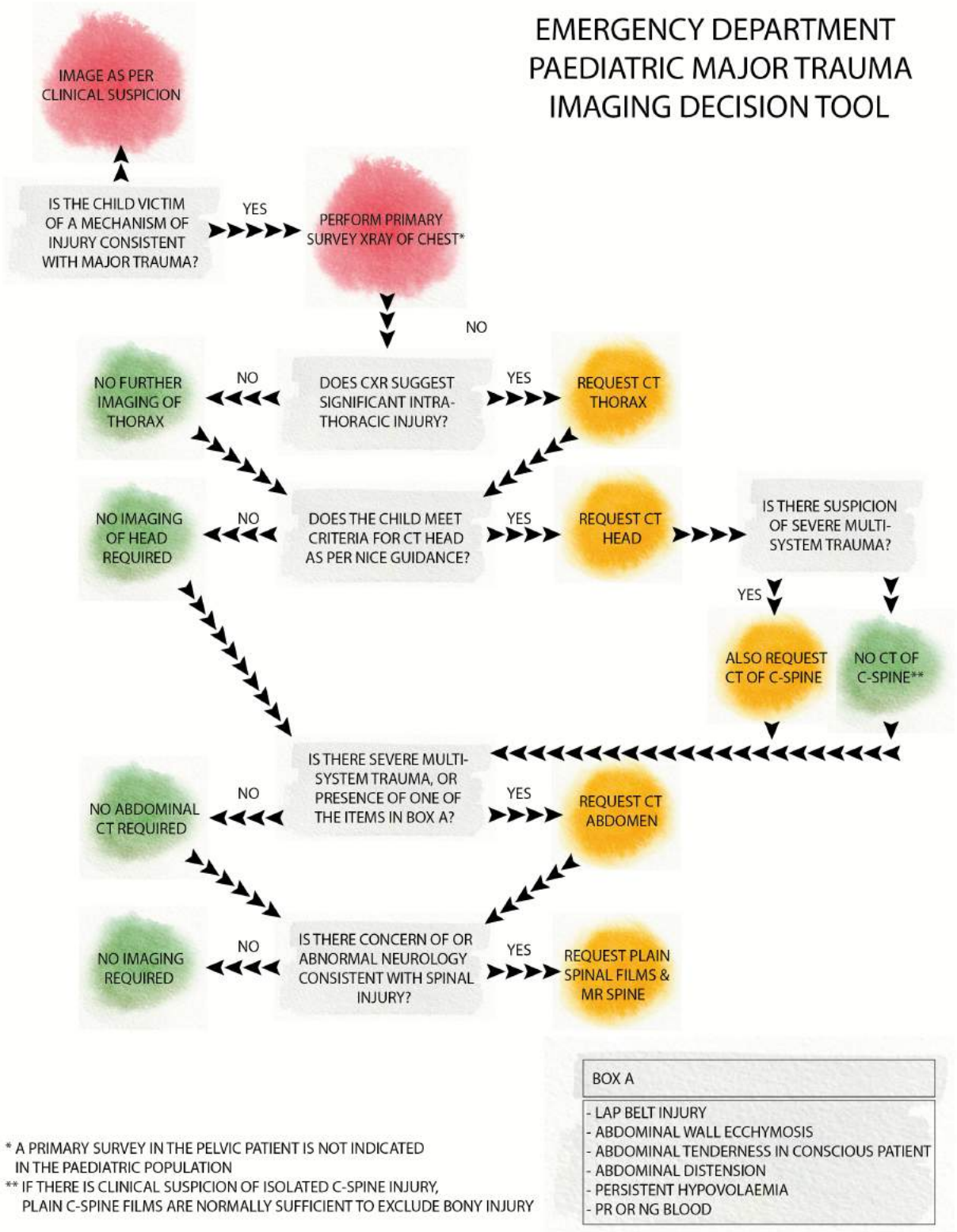


IMAGE copied with permission from author Robert James and RCR [12]

3.10. ANALGESIA

Factors for consideration

Pain can hinder assessment and diagnosis in children, causing agitation, tachycardia and distress. Alleviating pain early can exclude cardiovascular instability as a cause of altered signs and assist clinicians in their trauma assessment. It has the added benefit of also reducing patient and parental anxiety.

Infants and children may not be able to tell you "what is wrong". Use visual clues for children unable to tell you about their pain and give early analgesia to rule out causes of stress or tachycardia. Try to minimise separation from their parent or primary carer. Offer distraction techniques through use of bubbles or handheld devices with a favourite show or music.

Consideration should be given to different routes of administration whether that be oral, nasal, intravenous (IV) or use of regional/peripheral nerve blocks as an adjunct for analgesia.

For IV access consider the use of local anesthetic creams if time allows or cold spray to minimise distress. Involve play therapy where appropriate.

Ongoing analgesia needs must be considered in the form of patient controlled analgesia (PCA) or nurse controlled analgesia (NCA), according to the age/cognition of the patient. For opiate based analgesia on the wards rescue doses of naloxone for both respiratory depression and pruritus should be prescribed. Anti-emetics should also be prescribed.

Epidural analgesia has a role in paediatric trauma and has a particular benefit in children where opiate side effects should be avoided. Staff experienced in managing paediatric epidurals should be available for patient review 24/7

(See appendix for examples of PCA prescriptions in children.)

3.10.1 Guidelines for the Use of Intranasal Opiates

Intranasal Diamorphine

Indications: Useful for immediate relief of pain avoiding injection

Duration 45 minutes

Relative contraindications

Risk of loss of airway eg: in a drowsy child

Risk of respiratory depression

Risk of hypotension

Risk of decreased GCS

Dosage and Monitoring

Follow local protocol in terms of monitoring

Minimal monitoring: SaO2 and respiratory rate

Second dose – can be given after 20 minutes if ongoing pain and no respiratory depression or decreased GCS

Intra-Nasal Diamorphine

Dilute 10mg of Diamorphine with the specific volume of normal saline 0.9%

CHILDS WEIGHT	VOLUME OF NORMAL SALINE
10 Kg	1.9 mls
15 kg	1.3 mls
20 Kg	1.0 mls
25 Kg	0.8 mls
30 Kg	0.7 mls
35 Kg	0.6 mls
40 Kg	0.47 mls
45 Kg	0.42 mls
50 Kg	0.38 mls
55 Kg	0.34 mls
60 Kg	0.32 mls
65 Kg	0.30 mls
70 Kg	0.27 mls
80 Kg	0.24 mls

Instill 0.2mls of the solution into one nostril using a 1ml syringe (Dose = 0.1mg/kg in 0.2mls)

Intranasal Fentanyl

Use 100mcg/2ml strength fentanyl solution for intravenous use

First dose - 1.5 mcg/kg dose

A second dose may be administered 10 minutes after the first to provide adequate analgesia 0.75-1.5mcg/kg

3.10.2 Analgesia Dosing Guide: always consider potential contraindications

Analgesia	Dose
Paracetamol >10kg PO/IV Term neonate & <10kg Neonate 32—36/40	 15mg/kg QDS (max 60mg/kg/day) 10mg/kg TDS (max 30mg/kg/day) 7.5mg/kg TDS (max 25mg/kg/day)
Ibuprofen PO >1 month – 3 months > 3 months	 5mg/kg QDS (max 20mg/kg/day) 7.5mg/kg TDS (max 30mg/kg/day)
Oramorph	0.1mg/kg – 0.2mg/kg 3-4 hourly 0.2-0.4mg/kg 3-4 hourly ***post operatively***
Ketamine (Analgesia)	0.25mg/kg IV 5-10mg/kg Oral 5mg/kg IM
Ketamine (Sedation)	0.25-1mg/kg titrated to effect (full AAGBI monitoring)
Ketamine (Anaesthesia)	1-2mg/kg IV

3.11. REHABILITATION

Definitions:

Rehabilitation is a process of assessment, treatment and management of an individual (& their family/carers), with ongoing evaluation to support them achieve their maximum potential for physical, cognitive, social and psychological function, participation in society and quality of living.

Specialist rehabilitation is the total active care of patients with complex disabilities by a multiprofessional team who have undergone recognised training in rehabilitation, led/supported by a consultant trained and accredited in rehabilitation medicine.

(Ref: Specialist neuro-rehabilitation services: providing for patients with complex rehabilitation needs. London: British Society of Rehabilitation Medicine. 2010.)

Major trauma can cause complex and long-lasting effects including physical, cognitive, emotional, social and behavioural problems. Rehabilitation and after trauma care therefore form a vital part of the pathway for injured patients. Specialist rehabilitation following major trauma should be embedded in each trauma network. For most patients this will include leaving hospital with a formal rehabilitation prescription detailing advice, simple interventions and setting of expectations. For patients with more complex needs, prolonged input from multi-disciplinary teams will be needed and for a small subset in-patient rehabilitation may be required.

All patients are required to have a rehabilitation prescription completed by a recognised practitioner (usually a rehabilitation consultant /physio). This is a requirement for rehabilitation funding.

Current recommendations state that all patients with an ISS ≥9 should have their rehabilitation needs assessed and receive a rehabilitation prescription detailing their rehabilitation needs on leaving hospital. The rehabilitation prescription encompasses several different components, including:

A description of the injuries, relevant psycho-social background, risks and treatment to date

An individualized (text-based) description of rehabilitation needs/recommendations in sufficient detail to inform planning and delivery of on-going rehabilitation care.
Essential data collection using standardised data collection tools for audit and commissioning (ref: https://www.bsrm.org.uk/downloads/bsrm-core-standards-for-major-trauma-24-10-13-version1.4newlogo-forpublication-finalforweb-checked1-12-14.pdf)
Access to specialist rehabilitation services is extremely limited, so assessment by a rehabilitation consultant is paramount to ensure patients receive the care they require. In addition, there are a number of third party organisations including AfterTrauma, Headway, Child Brain Injury Trust who can form a vital part of the journey for major trauma patients.

3.11.1 NEURO REHABILITATION

Key Principles

Children and young people can experience a wide range of symptoms; physical, cognitive and psychosocial.
Rehabilitation for head injury should be discussed at the point of diagnosis and continued for as long as the child requires it
Care should be Consultant delivered involving a multi-specialty team
Discharge planning should involve the patient and family in consultation with all available community services, including the child's general practitioner The Child Brain Injury Trust (CBIT) offer clinical screening, advice, education and onward referral for children and young people following an acquired brain injury.
The Child Brain Injury Trust (CBIT) offer clinical screening, advice, education and onward referral for children and young people following an acquired brain injury Headway (https://www.headway.org.uk) is the UK-wide charity that works to improve life after brain injury by providing vital support and information services and can be useful to support patients and primary caregivers

Infants

Infants and children may not be able to tell you "what is wrong". Use visual clues for children unable to tell you about their pain and give early analgesia to rule out causes of stress or tachycardia. Try to minimise separation from their parent or primary carer. Offer distraction techniques such as bubbles or ipads with a favourite show or music.

Trauma can have a serious effect on the wellbeing of babies and toddlers. It can disrupt important aspects of child development that occur before the age of three years. These may include bonding with parents, as well as foundational development in the areas of language, mobility, physical and social skills plus managing emotions. Providing support to help the family rebuild a safe, secure and nurturing home will help the baby or toddler recover

Young People/Adolescents

Children and young people up to 18 years old make up one fifth of the UK's population. Young people, particularly teenagers are a social sensitive group. They engage in risk taking behavior, they may wish to be autonomous as they strive to become independent. They may have intense feelings but due to immaturity may struggle to express these.

For patients approaching adulthood it can be helpful to promote shared decision making and help them to set their own goals for recovery within the framework of clinical guidance. Non-physical repercussions of trauma may present later in the recovery phase. Therefore, it is important to promote open access to psychological support. Social media and online forums can feel less threatening to children in need. Liaising with schools to ensure educational support when discharged is helpful.

3.12. SAFEGUARDING/ NON-ACCIDENTAL INJURY (NAI)

3.12.1 Definition of Abuse

The World Health Organization distinguishes four types of child maltreatment: physical abuse; sexual abuse; emotional and psychological abuse; and neglect.
Safeguarding children is defined in Working Together to Safeguard Children as:
protecting children from maltreatment
preventing impairment of children's health or development
ensuring that children are growing up in circumstances consistent with the provision of safe and effective care
taking action to enable all children to have the best outcomes [13]

Non-accidental injury is a major cause of trauma in children and must be considered in all cases. It is particularly prevalent cause of injury in children under the age of one. These children are often under 6 months of age with high injury severity scores (particularly from severe head injuries). They have associated high mortality rates.

3.12.2 Suspicious signs which may be indicative of abuse

History

Trauma without adequate history or story not consistent with pattern of injury
Any traumatic injury in a non-ambulant baby/child
Preventable injury

Examination

Excessive bruising /pattern of bruising/fractures
Cigarette burns
Bite marks
Unusual injuries in inaccessible places e.g. neck, ear, hands, feet & buttocks

Intra-oral trauma (damage to frenulum)
Genital/anal trauma (where no clear history of direct trauma is offered or part of the clinical presentation)

Duties of the Trauma Team

To be aware of the local child protection mechanisms
To contact the named paediatrician or safeguarding nurse for advice on all cases (on call paediatrician or named/designated doctor/nurse *see local guidelines)
To act in the best interests of the child and the child's rights to be protected
To respect the rights of the child in terms of confidentiality
To be aware of the rights of those with parental responsibility

All staff with clinical responsibility for paediatric patients should be trained in safeguarding children.

Violence Reduction

3.12.3 Principles of violence reduction

Under 25s, especially males from deprived backgrounds, are disproportionately affected by interpersonal violence.[36] 16 year-olds are the most disproportionately affected; the rate of injury is 60% higher per year compared to the rest of the population of the UK.[37]
Homicide is the third leading cause of death in males aged under 19, after suicide and road traffic collisions.[38]
Every 2 to 3 days a woman is murdered in the UK by a current or ex-partner.
70% of under 19s witness real-world violence at least once a month. As many as a quarter of young people admit to knowing someone who carries a knife.[39]
Nationally, 40% of children who present with an adversity-related injury will re-present with further injury or self-harm.[40]
Traditional safeguarding processes do not always offer an adequate safety net for these patients on discharge from the hospital setting.

Exposure to violence can be linked to perceived safety in the community, and behavioral factors such as impulsivity and negative urgency. Identification of risk can protect young people from future episodes of violence.

Risk factors to consider

Is the history consistent with the injury?
Has the patient been to this, or any other hospital previously with similar presentations?
Does the patient appear to have sufficient insight into the potential severity of their injury?
When spoken to in confidence, does the patient express any anxieties about their safety on leaving hospital?
Does the patient's family express any concerns for their safety?

Violence reduction – a team-based approach

Patients do not always feel confident talking to health professionals about the social context of their safety and wellbeing. There is also a perception that healthcare staff may inform the police. The patient might believe this to be a greater threat to their safety than not talking at all. Even young people who abide by the law may be mistrustful of law enforcement – this in itself has complex roots.
An approach taken by a growing number of hospitals is to deploy a team of independent caseworkers, usually through a third party or the local authority. The caseworkers are generally from neighbouring communities or will have grown up with exposure to many of the problems that these young patients experience. This peer led support provides a sense of authenticity and trustworthiness to the young person, not always possible from clinical staff. Teams of this nature include the St Giles SOS Project, Oasis Youth Support, the Glasgow Navigator project and RedThread. Young people often disclose important information about their safety and wellbeing to the caseworkers, who can then co-ordinate future planning to safeguard them. They can also liaise

with the wider MDT once the patient feels more comfortable and trusting of hospital staff.

Responsibilities of clinical teams

Clinicians must begin to understand the social context which may have contributed to these injuries. By identifying risks that may contribute towards injury, hospitals can provide intervention services to support young people in maintaining health and wellbeing on leaving hospital. There is growing evidence that hospital-based violence intervention projects improve long term outcomes for young people at risk of violence victimisation and perpetration.

Key points for clinicians in order to promote violence reduction

Collect local data to understand the trends and patterns of violence.

Collaborate and share data with partner organisations, which will also help to build familiarity with services that are already available.

Provide intervention services for patients affected by violence through third party, local authority, or NHS funding streams. This service may be better suited to either emergency departments or inpatient wards, depending on the severity of injuries typically seen.

Good practice is to ensure a patient is safe to be discharged, not just medically fit to leave hospital.

If the patient is under 18, ensure the patient is referred to children's safeguarding services. If there are siblings or other children at home, ensure a safeguarding referral is completed for them also.

3.13. MAJOR INCIDENT AND MASS CASUALTY

A major incident is any occurrence that presents serious threat to the health of the community and requires implementation of special arrangements. It can result in a surge in patient numbers that is beyond the scope of "normal business operations".

Mass casualty events are typically events with casualties in the 100s where the normal major incident response must be augmented with extraordinary measures.

Recent events have reiterated the need for well coordinated plans to include children's services.
Every hospital should have an updated major Incident plan that includes children. Once a Major Incident is declared this plan should roll into action.

3.13.1 Management Principles

An in hospital triage area led by a senior clinician (ideally an Emergency Medicine Consultant) should be available to allow rapid assessment of injury severity, with allocation of a triage priority.

Pre- Hospital Triage

The categories allocated in the prehospital environment are as follows. (see appendix for triage flowchart)

Triage Category	Intervention Timing
P1	Immediate life-saving intervention
P2	Intervention within 2-4hrs
P3	Less serious: treatment can be delayed beyond 4 hours

For Major Incident, a Priority 4 or P4 or "Expectant Category" refers to "dead or obviously dying" patient. The decision to invoke the P4 casualty category in the pre-hospital setting for expectant patients will made by NHS England. This is usually a time limited category in exceptional circumstances. These patients will

not arrive as a priority transfer. They may have signs of life but have injuries incompatible with survival such as cardiac arrest, respiratory arrest with a pulse* (out of hospital), massive head injury. It can be psychologically extremely difficult to tag a child as expectant/deceased but there is also a need to treat vast numbers of injured children. Efforts must of course be put into the care of a dying child and support of affected family.
Using an objective triage tool during a major incident can help provide a framework and therefore emotional support for staff forced to make these decisions for children.
In major incidents patients are normally divided as being:
<12 years = paediatric
>12 years = adult

Age appropriate triage tools should be utilised – see appendix. Patients should be moved to appropriate treatment areas within the emergency department.
The main differences between adult and paediatric triage
In children, if positioning the airway does not restart ventilation, then give a trial of ventilation, as this may restart spontaneous ventilation. In adults, there is no trial of ventilation and the casualty is tagged expectant or dead
In children, only peripheral pulses should be used to assess circulation
In children, AVPU is used to assess mental status, not ability to follow commands

Non-ambulatory children may include:
infants (who can't walk yet)
children with developmental delay
children with acute injuries or chronic conditions prior to the incident that prevented them from walking

Constant review is necessary to account for deteriorating or improving patients.

3.13.2 Damage Control Surgery and Resuscitation

Damage Control Resuscitation

DCR is a systematic approach to the management of severely injured trauma patients that starts in the emergency room and continues through the operating room to the intensive care unit. The aim is to achieve haemodynamic stability and end organ perfusion through haemostatic resuscitation and arrest of bleeding. Until bleeding is controlled target end points may still fall outside the range of normal. The aim is to achieve values as close to normal as is physiologically possible.

Damage control surgery (DCS) is a concept of abbreviated laparotomy, designed to prioritise short-term physiological recovery over anatomical reconstruction in the seriously injured and compromised patient. Principles of DCS:

Early haemorrhage control of visible bleeding with an endpoint of haemostatic control only

Blood product resuscitation aimed at clinical endpoints rather than laboratory based figures. Partial correction is acceptable

Prioritising management of *hypothermia, acidosis, and coagulopathy*. All three have been proven to worsen outcome in traumatic major haemorrhage and should be prevented

Active warming strategies should be a priority (bair huggers, fluid warming devices, humidified gas)

Beyond DCS, priority should be given to stabilisation in critical care to normalise temperature, coagulation and pH

Return to theatre for definitive surgery once physiologically stable.

Radiological imaging is a valuable tool for assessing trauma patients and identifying internal injuries; however, imaging should not take precedence over DCR/DCS.

3.13.3 Other factors to consider

An emergency consent form should be completed for any child going to theatre under these circumstances
Two wristbands should be attached to the patient. Identity can be confirmed in awake patients.
Wristbands with trauma/major incident identity (depending on unit protocol) should remain on patient until patient true identity is established and linked to electronic systems (this is important for ordering blood and blood products initially issued under the allocated name).
Ensure WHO checklists are completed in theatre
Ensure patient tracking occurs via command hub and that appropriate communication occurs with police re identification and reunification with relatives
School uniforms with name/school name may help aid relocation with relatives

3.13.4 Communication

Clear communication is essential. In a major incident, traditional methods of communication; telephones, bleeps, WhatsApp may fail either from internal overuse, suspension of networks or saturation of switchboard from volume of calls. Contingency plans therefore must be in place to enable the transfer of information between staff for the purposes of clinical care. Consideration must also be given to the provision of information for relatives and the challenges of dealing with the press/media.

Administrative staff should be involved early in the cancellation of non-urgent elective operations and clinics.
All of the above should be included in the local major incident policy

3.13.5 Discharges

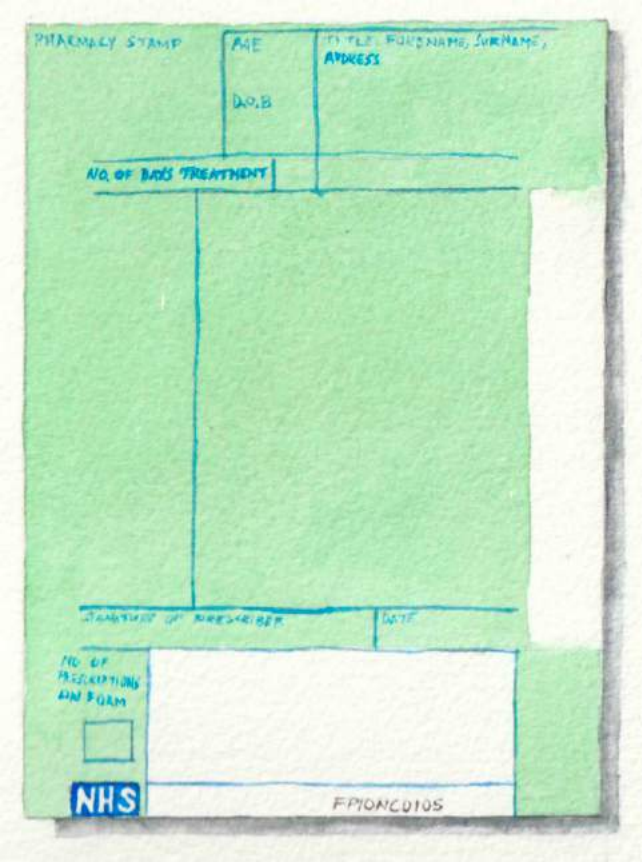
Trust planning for major incident should focus not just on admission but rapid discharge of existing patients in a timely fashion to create space and improve flow.

Additional staff assisting in a major incident may be allocated to "area or specialty-based working" with ward based doctors completing early discharge paperwork.

In some centres, FP10 prescriptions may be made available to allow patients discharged early to pick up medication from a pharmacy distant from the hospital site. There is potential for in-hospital pharmacies to become saturated with large numbers of requests. This allows them to concentrate on in patient management.

Local primary care trusts, social services, community teams should be part of this planning process as they will have a role following the perhaps early discharge of patients requiring support.

Example of Major incident Discharge planning initiative: Royal London Hospital (see appendix).



3.13.6 Trauma Unit: specific considerations

During a major incident, children may be managed in facilities not designated as specialist paediatric centres

Trauma units not used to receiving large volumes of paediatric patients should ensure that local policy includes management of a paediatric surge. Equipment stocks should be checked regularly ensuring capacity for major incident.

Some Trusts may also wish to consider *Broselow* grab bags for children, given potential skill mix issues at non specialised sites.

The overall response model should be facilitation of expert advice from non-receiving organisations with high level expertise to receiving organisations without this specific expertise.

Trauma units/local emergency hospitals will need to be prepared to immediately take uncomplicated inpatients from MTC's (particularly medical patients).

Major Incident Summary: Key Considerations:

Read your institution's major incident plan. Ensure this is up to date for paediatric admissions as well as adult

Ensure there is an up to date major incident telephone call list

Practice the major incident plan via table top exercises and simulation

Command, control, and communication are essential components of management in a major incident

Set up command centres in key areas to coordinate admission, flow to and from theatres, PICU, wards and discharge planning. A central command should coordinate complexities such as equipment, drugs, supplies

Allocate roles in advance of MI to all staff (ensure staff are familiar with their role in a MI via action cards)

Allocate staff to next shift planning during the initial phase

Consider how the department would manage on-going care of mass casualties (after the initial wave)

Ensure all patients undergo secondary and tertiary trauma surveys to identify missed injuries

Staff will require physical, social, and psychological support both during and after a major incident. Time should be allocated for debrief of clinical and non clinical staff involved

Consider cohorting care where adults (parents) have been injured with their children

3.13.7 Special Circumstances

Chemical, Biological, Radiological and Nuclear Incidents (CRBN)

CRBN management refers to the treatment principles used for Chemical, Biological, Radiological or Nuclear incidents. These events can produce large number of casualties and require a multi-disciplinary emergency service response, including police, ambulance service, fire and where necessary the military.

The Public Health England document on ***" CRBN; Clinical management and health protection"*** gives clear guidance for these services, including medical management for multiple different incidents. This document can be found below

Hyperlink Public Health England CBRN

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/712888/Chemical_biological_radiological_and_nuclear_incidents_clinical_management_and_health_protection.pdf

Key Principles for Management:

Ensure staff/personal safety first

Consider appropriate PPE

Decontaminate patient and remove clothing where necessary.

Manage injuries and clinical symptoms using standard resuscitation ABCs guidance.

3.14. Quick Reference Guide CRBN Drugs in Children [27,28]

Organophosphate Poisoning

Drug Treatment Atropine	Dose
Adults and Children > 12 years old	4.0-4.2 milligrams (8 x 500 / 7 x 600 microgram ampoules).
Children < 12 years old	50 to 75mcg/kg

Atropine may be given IV/ IM / IO

Doses repeated every five minutes until secretions are minimal and the patient is demonstrating effects of atropine (lungs are clear, heart rate is high/high normal and blood pressure is adequate).

Titrate the atropine to heart rate and bronchial secretions. Do not rely on pupil size for effect. Titrate to mild tachycardia for age. (Children tolerate atropine "poisoning" fairly well).[27,28]

In addition to atropine:

Drug Treatment Pralidoxime	Dose
Pralidoxime Chloride IV Loading Dose	30mg/kg (max 2g adult) over 30 minutes
Infusion	8mg/kg/hour (approx. 0.5g/hour in adults) for 12-24 hours (restart if deterioration after stopping)

Control of convulsions	Dose
Diazepam IV	0.1--0.3mg/kg (10mg – 20mg in adults)
Lorazepam IV	0.1mg/kg (4mg in adults)
Midazolam IV	0.05 to 0.15mg/kg (5-10mg in adults)

Opiate poisoning

Naloxone	Dose
Adults (children >12y)	Initial dose 400mcg, if no response after 60 seconds give a further 800mcg. If still no response administer a further 800mcg (if no response after total 2mg) give a further 2mg

Children < 12y	Initial dose 100mcg, if no response after 60 seconds administer a further 100mcg if still no response give a further doses until satisfactory response or max 2mg

Cyanide poisoning

Cyanide Poisoning Drug Doses	**Dose**
MILD Sodium Thiosulphate IV	>12 years: 12.5g IV over ten minutes <12 years: 400mg/kg (0.8ml/kg of 50% solution, or 1.6ml/kg of 25% solution)
SEVERE 1) Dicobalt Edetate IV	>12 years: 20ml of 1.5% solution (300mg) IV over 1 minute followed immediately by 50ml of 50% dextrose < 12 years : 4mg/kg IV over 1 minute followed by 2ml/kg bolus of 10% glucose
SEVERE (separate IV line) 2) Hydroxocobalamin (Cyanokit) IV	>12 years: 5g over 15 minutes repeated x 1 if required <12 Years 70mg/kg (max 5g) over 15 minutes repeated x 1 if required

For Biological Antibiotics regimens (see hyperlink below)

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/712888/Chemical_biological_radiological_and_nuclear_incidents_clinical_management_and_health_protection.pdf]

Blast Injuries

Drugs

Consider tetanus immunisation status for all blast injuries/tetanus prone wounds.

Give antibiotics (see hyperlink for area of injury and microguidance).

Satellite PCCU (An Innovation in view of high ventilation requirements for CBRN)

In the event of a major incident (MI), and in particular a CBRN event, there is a strong likelihood that there will be multiple paediatric casualties requiring intensive treatment. In light of this the pressure will be on the ED to maintain the flow of patients. Availability of PCCU beds will be a rate limiting step, with many patients unsuitable for management on the general wards. In light of this, advanced planning should be undertaken with consideration given to the creation of a temporary satellite PCCU.

This concept has been explored in certain centres, where paediatric theatres and recovery areas have been tested via simulation as satellite intensive care units

Factors for consideration may be dependent on the type of MI; CBRN, pure trauma or combination of the two

Early decisions should centre around theatre availability for incoming trauma/emergencies requiring imminent surgery versus utilisation of theatres or anaesthetic rooms for peri-operative/PICU management. Additional ventilators/anaesthetic machines can be utilised in areas such as recovery for excess numbers of patients being treated

In the case of an incident involving use of nerve agents, a scavenger system may be required to neutralize the agent. If recovery is unable to provide scavenger capabilities or provide additional ventilators, then medically ventilated patients should be held in theatre suites/anaesthetic rooms until level 3 beds become available

Early consideration should be given to equipment availability should an overspill of patients be anticipated from PCCU. This should be planned for in advance to avoid compromised

The decision to set up a satellite PCCU should be taken early following conversations between theatres, PCCU and emergency department regarding volume of casualties and maximum bed availability. Ideally the sickest patients

should be cohorted on the PICU with less dependent patients in the satellite area.

Appendix

I. Anaesthesia Drugs and Dosages

IV or IO if no IV access

Induction Agent	**Dose**
Propofol	2-4mg/kg
Thiopentone	2-7mg/kg
Ketamine	1-2mg/kg

Opiates	**Dose**
Morphine	0.05-0.1mg/kg IV
Oramorph (P.O)	0.2-0.4mg/kg PO
Fentanyl	0.5-1mcg/kg IV (Consider Increased dose for induction if haemodynamically unstable: 2-3mcg/kg – obtunds response to laryngoscopy and allows decreased doses of induction agent)
Alfentanil	5-10mcg/kg

Muscle Relaxant	**Dose**
Suxamethonium	1-2mcg/kg
Rocuronium	1mg/kg
Atracurium	0.5mg/kg
Vecuronium (bolus) Vecuronium (infusion)	0.1mg/kg 1-3mcg/kg/minute

Analgesia (see analgesia section)	**Dose**
Paracetamol >10kg	15mg/kg IV QDS
Diclofenac (Voltarol) (slow IV)	1mg/kg TDS
Ibruprofen	7.5mg/kg QDS

Emergency Drugs	**Dose**

Atropine	20mcg/kg IV
Adrenaline	0.1ml/kg 1:10,000
Glucose (dextrose 10%)	2ml/kg bolus
Infusions	
Adrenaline/Noradrenaline	0.01-1mcg/kg/min (Make up 0.3mg/kg in 50 mL: 1 mL/hr = 0.1mcg/kg/min)
Dopamine	5-20mcg/kg/min (Make up 15mg/kg in 50 mls: 1ml/hr = 5mcg/kg/min)
Morphine	10-40mcg/kg/hr (Make up 1mg/kg in 50 mL: 1 mL/hr = 20 mcg/kg/hr)
Midazolam	1-4mcg/kg/minute (6 mg/kg in 50 mL: 1 mL/hr = 2 mcg/kg/min. Max 250 mg in 50 mL)
Mannitol (cerebral oedema)[47]	0.25-1.5g/kg 0.25-2g/kg if (>12-18yyears)
Hypertonic Saline 3% (or pre-made 2.7%)	3mls/kg [46]

Antiemetics	Dose
Ondansetron	0.1mg/kg IV TDS
Cyclizine	1mg//kg IV TDS (slow infusion) max 50mg
Dexamethasone (asleep patients)	0.1mg/kg

II. PCA/NCA Doses (example guideline)

Morphine Sulphate	
PCA	Morphine sulphate 1mg/kg made up to 50ml with 0.9% sodium chloride = 20mcg/kg/ml
NCA	
Children >50kg	Morphine sulphate 50mg made up to 50ml with 0.9% sodium chloride = 1mg/ml

INITIAL PROGRAM	LOADING DOSE		BACKGROUND INFUSION		BOLUS DOSE		LOCK OUT (mins)
	mcg/kg	ml	mcg/kg/hr	ml/hr	mcg/kg	ml	
PCA	50-100	2.5-5	2-8	0.1-0.4	10-20	0.5-1	5
NCA	50-100	2.5-5	10-20	0.5-1	10-20	0.5-1	20

Morphine Sulphate + Ketamine	
PCA	**Ketamine** 1mg/kg & **Morphine sulphate** 1mg/kg made up to 50ml with 0.9% sodium chloride = 20mcg/kg/ml
NCA	
Children >50kg	**Ketamine & Morphine sulphate** 50mg made up to 50ml with 0.9% sodium chloride = 1mg/ml

INITIAL PROGRAM	LOADING DOSE		BACKGROUND INFUSION		BOLUS DOSE		LOCK OUT (mins)
	mcg/kg	ml	mcg/kg/hr	ml/hr	mcg/kg	ml	
PCA	50-100	2.5-5	2-8	0.1-0.4	10-20	0.5-1	5
NCA	50-100	2.5-5	10-20	0.5-1	10-20	0.5-1	20

Fentanyl	
PCA	Fentanyl 1ml/kg made up to 50ml with 0.9% sodium chloride = 1mcg/kg/ml
NCA	
Children >50kg	Fentanyl 50ml

INITIAL PROGRAM	LOADING DOSE		BACKGROUND INFUSION		BOLUS DOSE		LOCK OUT (mins)
	mcg/kg	ml	mcg/kg/hr	ml/hr	mcg/kg	ml	
PCA	0.5-1	0.5-1	0.5	0.5	10-20	0.5-1	5
NCA	0.5-1	0.5-1	1	1	10-20	0.1	20

Fentanyl + Ketamine	
PCA	**Ketamine** 1mg/kg **Fentanyl** 50mcg/kg (=1ml/kg) made up to 50ml total volume in syringe with 0.9% normal saline
NCA	
Children >49kg	**Ketamine** 50mg (=1ml) & Fentanyl 2450mcg (=49mls) Total volume in syringe 50mls

INITIAL PROGRAM	LOADING DOSE ml	BACKGROUND INFUSION ml/hr	BOLUS DOSE ml	LOCK OUT (mins)
PCA	0.5-1	0.5	0.5	5
NCA	0.5-1	1	1	20

PCA/NCA Nursing Guidelines

AGE	Min RR
<3month	25
3m-1yr	20
1-5	15
>5	10
>12	8

PRN Drug	Dose
Naloxone (pruritus/urinary retention)	0.5mcg/kg
Naloxone (respiratory depression)	4mcg/kg
Ondansetron	100mcg/kg (IV/PO) 8hourly
Diazepam (muscle spasm – ortho)	100mcg/kg PO 6 hourly

	Sedation Score	Action
S3	Asleep/ unrousable	Stop infusion Stimulate patient Administer Oxygen Call Anaesthetist Prepare Naloxone
S2	Asleep but rousable	Continue saturation monitoring
S1	Drowsy / asleep but moves spontaneously	Continue saturation monitoring
S0	Awake	Continue

III. Paediatric Normal Values and Calculations

WET FLAGS

Weight	See below
Energy	4 joules per Kg (J/Kg)
Tube	Age in years / 4 + 4 (cuffed) or + 4.5(uncuffed) (note newer formula more frequently used for current population) Size 3.0 – 3.5 tube for newborn
Fluid	10mls / Kg
Lorazepam	0.1mg / kg
Adrenaline	0.1mls /kg of 1:10,000
Glucose	2mls/kg

Normal Values

Age in Years	Respiratory Rate	Heart Rate	Systolic BP (50th centile)
<1	30 - 40	110 - 160	80 - 90
1–2	25 - 35	100 - 150	85 - 95
2–5	25 - 30	95 - 140	85 - 100
5 –12	20 - 25	80 - 120	90 - 110
> 12	15 - 20	60 - 100	100 - 120

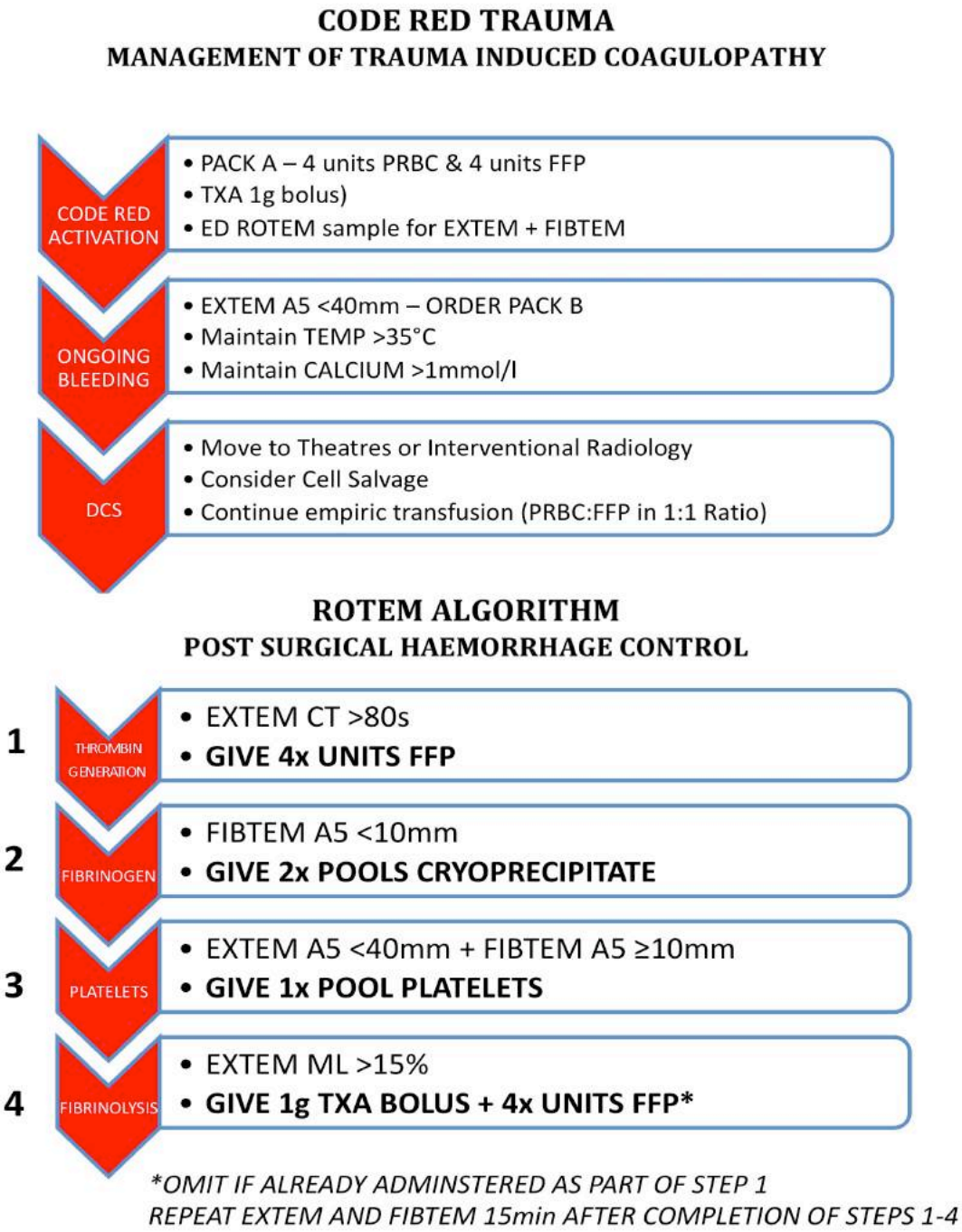
Calculating Weights

Age in Years	Weight Calculation
<1	Weight (in kg) = (0.5 x age in months) + 4
1–5	Weight (in kg) = (2 x age in years) + 8
6 - 12	Weight (in kg) = (3 x age in years) + 7

CVC Access [44]

CVC Sizes		
Age	**Weight**	**CVC size**
0-6 months	<10kg	4 Fr
6m-4years	10-20kg	4.5 Fr – 5 Fr
4-12years	20-40kg	5 Fr
>12years	>40 kg	7 Fr

IV. Sample ROTEM Protocol RLH >50Kg



V. Sample Major Incident Discharge Pathway (RLH)

MAJOR INCIDENT DECLARED

Watts app cascade from PICU Doctors / Nurses / Ward Clerks - nominate 2nd Staffing Lead PICU run watts app and staff next shift

OUT OF HOURS DISCHARGE PLANNING NURSE LEAD

1. Bed Board meeting (30 minutes duration with senior doctor and nurse to identify Immediate discharges.

2. PICU to identify how many Step downs they have.

2. Phone 7th floor command with Provisional Numbers as soon as Discharge meeting concluded.

3. D start planning decant of patients to – C E F

4. Wards to determine how many immediate home and how many to discharge lounge awaiting pharmacy (how many staff needed for discharge lounge/to ratio of parents?) inform command how many – review which of the patients staying need RLH specifically which could repatriate to whipps etc

5. leads to phone pharmacy to identify estimate for TTA's from pharmacy

6. leads to phone command with numbers – once confirmed

As soon as more Paediatric Foctors arrive Nominate to AREA based working E / F / C / D / A&E or PICU

As soon as second SN arrived nominate to Management / Shift planning

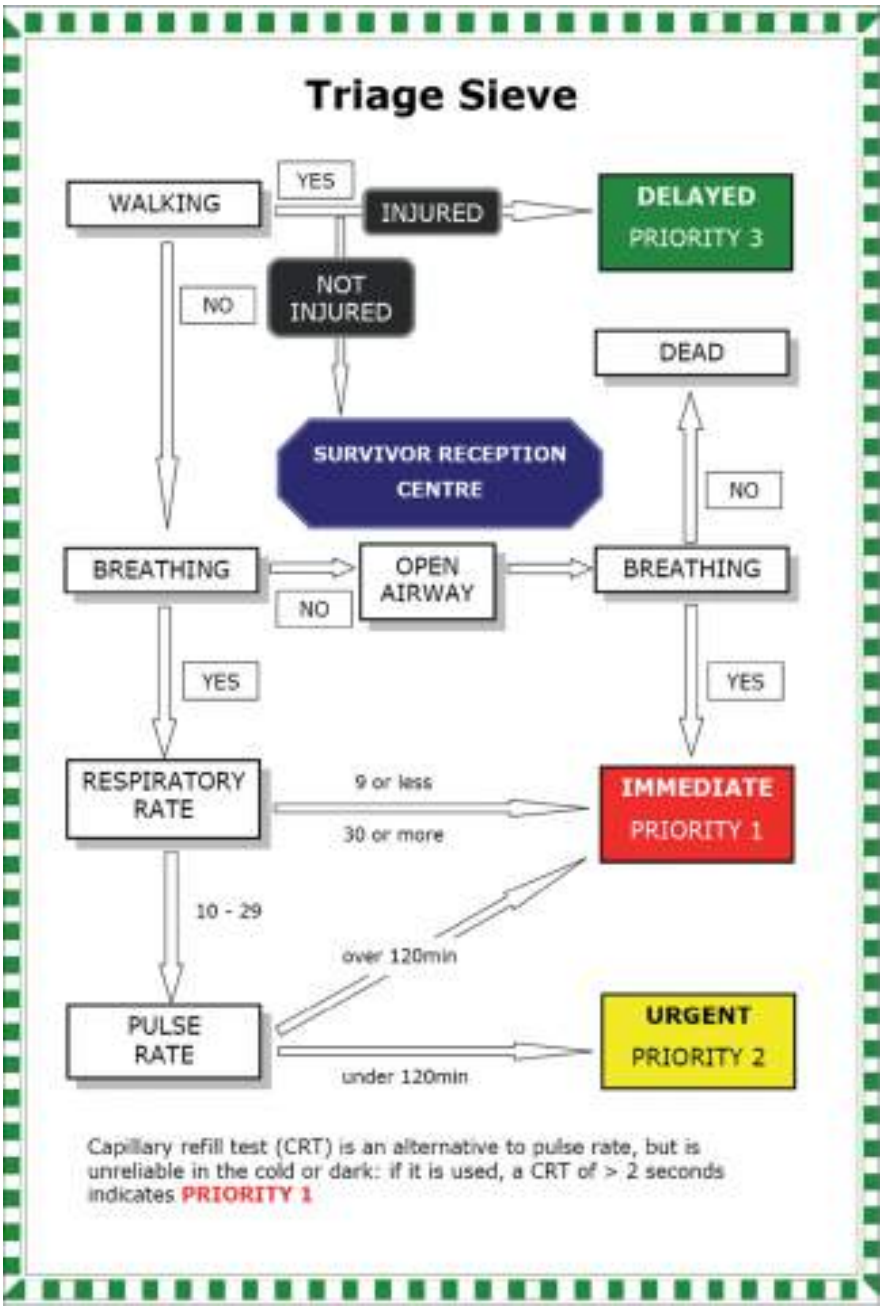
Location	Bed Meeting + Ward Clark
E	Lead Nurse E
F (to go to E With board)	Lead Nurse F Consultant
C	Lead Nurse PASSU CONSULTANT *(liaise with speciality consultants to start facilitating discharges)*
D	Lead Nurse SPR (ward) 1045

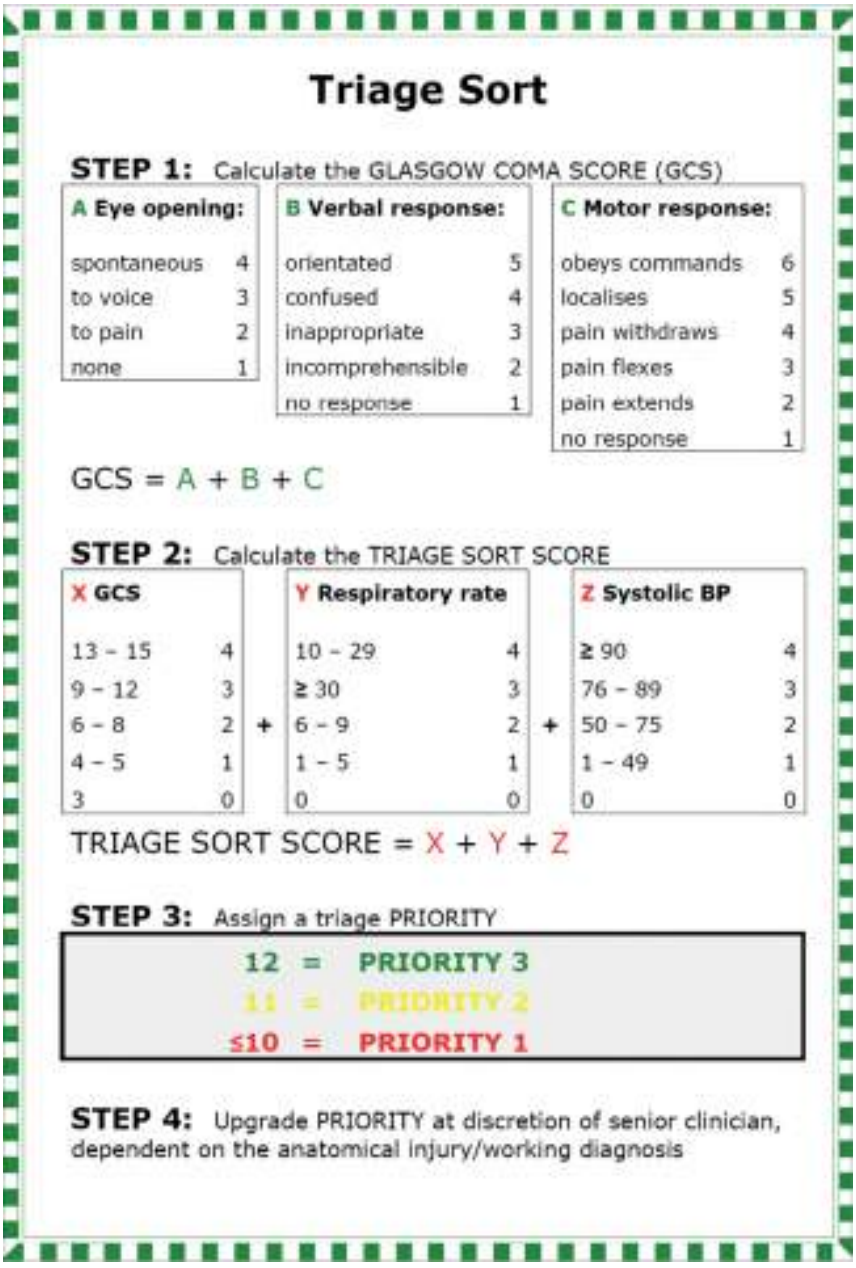
Location	Staff
PICU	Consultant Lead nurse

LOCATION	Staff
Attend wards Where your Patients Are.	Speciality Consultant ON CALL

LOCATION	Staff
A&E	1052 liase with 7D gym (review admission numbers ED - DW Lead Nurse in ED

VI. Examples of Pre-hospital Triage tools in major incidents: (NARU Sieve – initial pre hospital triage category, SORT secondary triage after initial SORT) Jumpstart. [41,42]





Triage Sort

STEP 1: Calculate the GLASGOW COMA SCORE (GCS)

A Eye opening:		B Verbal response:		C Motor response:	
spontaneous	4	orientated	5	obeys commands	6
to voice	3	confused	4	localises	5
to pain	2	inappropriate	3	pain withdraws	4
none	1	incomprehensible	2	pain flexes	3
		no response	1	pain extends	2
				no response	1

GCS = A + B + C

STEP 2: Calculate the TRIAGE SORT SCORE

X GCS			Y Respiratory rate			Z Systolic BP	
13 - 15	4		10 - 29	4		≥ 90	4
9 - 12	3		≥ 30	3		76 - 89	3
6 - 8	2	+	6 - 9	2	+	50 - 75	2
4 - 5	1		1 - 5	1		1 - 49	1
3	0		0	0		0	0

TRIAGE SORT SCORE = X + Y + Z

STEP 3: Assign a triage PRIORITY

12	=	PRIORITY 3
11	=	PRIORITY 2
≤10	=	PRIORITY 1

STEP 4: Upgrade PRIORITY at discretion of senior clinician, dependent on the anatomical injury/working diagnosis

Immediate = P1 Delayed = P2 Minor = P3

References

1. London Major Trauma System Available at URL: [http://www.c4ts.qmul.ac.uk/London-trauma-system/london-trauma-system-map]
2. London Major Trauma System Available at URL: [http://www.c4ts.qmul.ac.uk/downloads/network-dox/tanq-june.pdf]
3. London Ambulance Service Paedatric Guidelines Available at URL:[https://www.londonambulance.nhs.uk/document-search/paediatric-care-policy/]
4. Difficult Airway Society (DAS) Guidelines. Available at URL: [https://das.uk.com/guidelines/paediatric-difficult-airway-guidelines]
5. CT indications in head injury. Available at URL: [https://www.nice.org.uk/guidance/cg176]
6. Boast Guidelines for Orthopedic Trauma. Available at URL: [https://www.boa.ac.uk/publications/boa-standards-trauma-boasts/]
7. NICE Trauma Guideline (NG37) "Fractures (complex): Dif and management"
8. NICE Trauma Guideline (NG38) "Fracture (non-complex): assessment and management".
9. London and South East England Burns Network. Available at URL: [http://www.lsebn.nhs.uk]
10. Royal College of Radiologists Guidelines. Available at URL: [https://www.rcr.ac.uk/system/files/publication/field_publication_files/BFCR(14)8_paeds_trauma.pdf]
11. Blunt Abdominal Trauma. Available at URL:[https://www.uptodate.com/contents/pediatric-blunt-abdominal-trauma-initial-evaluation-and-stabilization]
12. Paediatric Radiology. Available at URL: [https://www.rcr.ac.uk/publication/paediatric-trauma-protocols]

13. Safeguarding Children. Available at URL: [https://www.gov.uk/government/publications/working-together-to-safeguard-children--2]
14. C-spine clearance in Children NICE guidelines. Available at URL: [https://pathways.nice.org.uk/pathways/head-injury/investigation-for-injuries-to-the-cervical-spine-in-children-with-head-injury]
15. Rickard AC, Vassallo J, Nutbeam T, *et al*. *Emerg Med J* Epub doi:10.1136/ emermed-2017-207226
16. Paediatric Transfers. Available at URL: [https://www.rcoa.ac.uk/system/files/GPAS-2019-10-PAEDIATRICS.pdf]
17. Hospital Transfers AAGBI. Available at URL: [https://www.aagbi.org/sites/default/files/interhospital09.pdf]
18. Tranexamic acid in Children. Available at URL: [https://www.rcem.ac.uk/docs/External%20Guidance/10k.%20Major%20trauma%20and%20the%20use%20of%20tranexamic%20acid%20in%20children%20Evidence%20statement%20(RCPCH,%20Nov%202012).pdf]
19. Potassium replacement in Children. Available at URL: [https://www.uptodate.com/contents/causes-clinical-manifestations-diagnosis-and-evaluation-of-hyperkalemia-in-children?sectionName=Cardiac%20conduction%20abnormalities&topicRef=85908&anchor=H85958377&source=see_link#H85958377]
20. Patterns of moderate and severe injury in children after the introduction of major trauma networks Samantha Jones, Sarah Tyson, Michael Young, Matthew Gittins, Naomi DavisArch Dis Child 2018. doi:10.1136/ archdischild-2018-315636
21. The spleen L Gent, MBBS BSc (Hons) FRCA P Blackie, BSc (Hons) MBBS FRCA FFICM EDIC*BJA Education*, Volume 17, Issue 6, June 2017, Pages 214–220, https://doi.org/10.1093/bjaed/mkw072**Published:**16 February 2017
22. Injury Severtiy Scores. Available at URL : [http://www.aast.org/Library/TraumaTools/InjuryScoringScales.aspx]
23. Trauma Who Cares: Available at URL: [www.ncepod.org.uk/2007report2/Downloads/SIP_report.pdf]

24. Tinkoff G, Esposito TJ, Reed J, et al. American Association for the Surgery of Trauma Organ Injury Scale I: spleen, liver, and kidney, validation based on the National Trauma Data Bank. *J Am Coll Surg.* 2008;207:646 – 655.
25. Stylianos S. Evidence-based guidelines for resource utilization in chil- dren with isolated spleen or liver injury. The APSA Trauma Committee. *J Pediatr Surg.* 2000;35:164–167; discussion 167–169.
26. Stylianos S. Compliance with evidence-based guidelines in children with isolated spleen or liver injury: a prospective study. *J Pediatr Surg.* 2002;37:453– 456.
27. CBRN. Public Health England. Available at URL: [https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/712888/Chemical_biological_radiological_and_nuclear_incidents_clinical_management_and_health_protection.pdf]
28. Moshiri M Darchini-Maragheh, Balali-Mood M. Advances n toxicology and medical treatment of chemical warfare nerve agents. Daru. 2012; 20(1): 81. Published online 2012 Nov 28. doi: 10.1186/2008-2231-20-81
29. Advanced Life Support Group. *Advanced Paediatric Life Support: A Practical Approach to Emergencies (APLS)* 6th Edition. Wiley-Blackwell 2016
30. 2. NICE Guideline NG41 *Spinal injury: assessment and initial management*. Available from URL: https://www.nice.org.uk/guidance/ng41/chapter/recommendations#assess ment-and-management-in-prehospital-settings. Accessed 07.04.16.
31. Royal college of Emergency medicine C-spine in Children. Available from URL: [https://www.rcem.ac.uk/docs/RCEM%20Guidance/Paediatric%20Trauma%20-%20Stabilisation%20of%20the%20Cervical%20Spine%20(Aug%202017).pdf]
32. Trauma. Available from URL:[https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3405458/]
33. NICE Spinal injury in children. Available at URL: [https://www.nice.org.uk/guidance/ng41/resources/spinal-injury-assessment-and-initial-management-1837447790533]

34. ELoTS study: Cole, E., Lecky, F., West, A. et al. (2016) The impact of a pan-regional inclusive trauma system on quality of care. Annals of Surgery, 264 (1). pp. 188-194. ISSN0003-4932 https://doi.org/10.1097/SLA.0000000000001393
35. Changing the System - Major Trauma Patients and Their Outcomes in the NHS (England) 2008–17 Christopher G. Moran et al.
36. Vuillamy P, Faulkner M, Kirkwood G, West A, O'Neill B, Griffiths M, Moore F, Brohi K, Temporal and geographic patterns of stab injuries in young people: a retrospective cohort study from a UK major trauma centre, BMJ Open (2018)
37. MOPAC, London Knife Crime Strategy, policy document, The Mayor's Office (2017)
38. Public Health England, Health profile for England: 2018, C2: trends in mortality (2018)
39. The Youth Violence Commission, *Interim Report* (2018)
40. Herbert A, Gilbert R, Gonzalez-Izquierdo A, Li L, Violence, self-harm and drug or alcohol misuse in adolescents admitted to hospitals in England for injury: *a retrospective cohort study*, BMJ Open (2015)
41. National ambulance response. Triage. Available at URL: [https://naru.org.uk/naru-input-to-new-triage-sieve/]
42. Romig LE. Pediatric triage, a system to JumpSTART your triage of young patients at MCIs. JEMS. 2002 Jul;27(7):52-8, 60-3
43. Major incident NHS England. Available at URL: [https://www.england.nhs.uk/wp-content/uploads/2018/12/version1__Major_Incident_and_Mass_casualty_guidelines-Nov-2018.pdf]
44. CVC line sizes in children accessed from URL Dec 2019: [https://www.rch.org.au/uploadedFiles/Main/Content/anaes/choosing_CVC_and_PICC_size.pdf]
45. http://bulletin.facs.org/2018/06/atls-10th-edition-offers-new-insights-into-managing-trauma-patients/
46. https://www.evelinalondon.nhs.uk/resources/our-services/hospital/south-thames-retrieval-service/Hypertonic-Saline-2017.pdf
47. https://www.sbp.com.br/fileadmin/user_upload/pdfs/british_national_formulary_for_children_2011-2012.pdf

48. https://www.boa.ac.uk/uploads/assets/ac635861-a657-48f2-aeab0276534e4e37/e3bd08bb-bba6-4074 8ba0d08f53dc9d2c/management%20of%20arterial%20injuries%20associated%20with %20fractures%20and%20dislocations.pdf