Yorkshire and Humber
Paediatric Major Trauma Guidelines

Produced in collaboration with

The Yorkshire and Humber Paediatric Critical Care Operational Delivery Network
The West Yorkshire Major Trauma Network
The South Yorkshire Major Trauma Operational Delivery Network
The North Yorkshire and Humberside Major Trauma Network

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1. Introduction

Injury is the most frequent cause of death in children above the age of one in the United Kingdom.

Major Trauma Networks have been established in England with the aim of getting the patient to the "right place at the right time for the right care."

Major Trauma triage protocols are in place so that most children will be transferred directly into Major Trauma Centres. The Major Trauma Centres (MTCs) have the facilities to provide resuscitation, emergency surgery and interventional radiology with consultant-led trauma teams, massive transfusion protocols, and immediate access to operating theatres and intensive care. Patients with longer transfer times are taken to the nearest Trauma Unit. In Yorkshire and Humber this combined with children being taken by parents to the nearest Emergency Department means that up to 50% of paediatric major trauma will present to the nearest Trauma Unit or Emergency Department attached to a hospital with minimal trauma services.

This guideline is intended to be used as a working document to provide guidance for Trauma Units and Major Trauma Centres in Yorkshire and Humber receiving children with major trauma. The aim of the guideline is to:

- ✓ Improve equity of access to Major Trauma Centres and critical care services
- ✓ Ensure consistent application of standards across the region
- ✓ Improve experience and quality of care and outcomes for children and their families
- ✓ Enhance collaborative networking between professionals

The guidance covers the paediatric major trauma patient from first point of contact at any Emergency Department until transfer to the specialist service is completed.

It includes information on:

- ✓ Current patient pathways
- ✓ Who to contact and how
- ✓ Tips from experts
- ✓ Web links to more detailed network guidelines where they exist

2. Network referral pathways

The region consists of:

- Two Adult Major Trauma Centres - Hull Royal Infirmary and Northern General Hospital
- One Paediatric Major Trauma Centre - Sheffield Children's Hospital
- One Combined Adult and Paediatric Major Trauma Centre - Leeds General Infirmary
- Multiple Trauma Units organised into three distinct trauma networks
- Emergency Departments attached to Local Emergency Hospitals in the West and South Yorkshire Major Trauma Networks who do not routinely receive patients with traumatic injuries via the ambulance service

Some of the pathways are straightforward and others are complex, such as vascular injury and burns. The guideline contains flow charts to help the user know who to contact and which pathway to follow.

3. Network referral process

Children with major trauma need to be stabilised appropriately and to get to the right Major Trauma Centre quickly for definitive care. Too many phone calls can introduce unacceptable delays that may impact upon outcomes.

Non MTCs should refer any patient who they feel is beyond their resources to manage. The Major Trauma Networks have agreed an **IMMEDIATE TRANSFER POLICY**. The MTC default position is to accept all referrals.

How to refer (time critical / ED to ED referrals)

- Ensure the patient is being prepared for transfer (see section on Secondary trauma transfers).

In parallel:

- The most senior Emergency Department doctor available should make the referral and the most senior MTC Paediatric ED doctor should receive the referral.
- All referrals should be made via Embrace by calling **0114 305 8200** selecting the TRAUMA [1] option.
- Embrace will immediately arrange a conference call between the referring hospital clinician and the appropriate MTC clinician. If necessary, specific additional clinicians (including the Embrace clinician on call) can be included in the call.
- The conference call allows referral and the provision of any necessary clinical advice regarding stabilisation and transfer.
- The role of Embrace is to facilitate referral but, in most cases, Embrace will not provide a time critical transfer, and this must be done via the relevant ambulance service.
- The referral should be made in a structured fashion (eg. ATMIST). Referrals in the WYMTN to the Leeds MTC should also be accompanied by an online Patient Pass referral to ensure robust documentation of demographics, physiology, injuries and imaging reports.
- If there is high suspicion of cardiac or vascular injury, the Sheffield MTC clinician may ask to conference in the Leeds MTC clinician for a decision on whether to transfer direct to Leeds
- The call should conclude with a clear statement of what has been agreed including emphasis that Embrace will not (in the majority of cases) be doing the transfer.

*For children aged 12-15 at Sheffield Children's Hospital who require emergent treatment at Sheffield Teaching Hospitals NHS Foundation Trust (isolated traumatic injury requiring emergent,

[1] There has been some confusion between "Trauma' and 'Major Trauma' in the past. This pathway covers **any patient who has suffered physical injury** and requires transfer to the MTC.

time-critical cardiac surgery, peripheral vascular surgery or interventional radiology) please refer to the Standard Operating Procedure southyorkshiremtn.nhs.uk/seecmsfile/?id=658

Arranging transfer

Note that all networks have agreed a 'send & call' approach. This means that in time critical cases the TU should arrange transfer prior to or in parallel with referral.

- The transferring team (TU / LEH) call their local ambulance service and state "*Emergency Interfacility Transfer for Child Major Trauma Victim*"
    - Yorkshire Ambulance Service 0330 330 0276
    - East Midlands Ambulance Service 0115 967 5097
- Almost all major trauma transfer requests will require a CATEGORY 2[2] response.
- If, in the opinion of the senior clinician in charge, the patient requires a category 1 response then they should request that "*the incident is escalated to a team leader or a clinical manager to call back to review with the senior clinician".*
- The accepting Emergency Physician at the MTC makes any necessary referrals to MTC specialist teams as appropriate to alert them to the patient being transferred.
- Transfer does not require the identification of a specific bed at the MTC and bed management concerns must not delay transfer.
- Unnecessary imaging (ie. imaging that will not change immediate management priorities) should not be performed prior to transfer.

Decisions not to transfer

- On occasion the referral process will lead to a decision that transfer to the MTC is not required and that definitive care can be delivered at the referring hospital.
- Such a decision does not prevent re-referral at any time if the clinical situation changes or the TU clinicians feel the initial decision was not in the patient's best interests.

Stop, Sort & Go

- Ideally all patients meeting the criteria of the Major Trauma Triage Tool should be taken directly to the Major Trauma Centre. On occasion a patient will be too unstable and may benefit from an initial intervention at the nearest Trauma Unit (but **NOT** Local Emergency Hospital). An example would be a patient whose airway cannot be maintained by the interventions available to the pre-hospital team.

[2] Immediate life, limb or sight (globe trauma) threatening (ILT) situations that require immediate management in another healthcare facility should receive this level of response. Other examples include patients going directly to theatre for immediate neurosurgery, primary percutaneous coronary intervention, stroke thrombolysis, mechanical thrombectomy, surgery for ruptured aortic aneurysm, emergency 4 laparotomy, surgery for ectopic pregnancy, limb or sight saving surgery or mental health patients being actively restrained.

- The decision to not proceed to the MTC will be made by the pre-hospital team (with the support of the major trauma desk where available). The TU **must** be pre-alerted.
- Once the immediate clinical priority has been managed the Trauma Team Leader of the TU is responsible for deciding the next course of action – which will either be immediate transfer to the MTC or local investigation and initial management.
- Immediate transfer will ideally be performed by the initial ambulance crew who will have remained with the patient. TU staff (eg anaesthetist) may be required to go with the patient.

4. Major Incident planning

Staff in all hospitals receiving paediatric major trauma patients should be familiar with their own Major Incident Policy and action cards. It should be noted that in the event of a Mass Casualty Incident, different rules may apply.

5. Blood products and massive haemorrhage – see Appendix 1 for additional resources

Initial fluid resuscitation of trauma patients should be with blood.

Remember the new 2-Sample rule.

This guideline is intended to supplement local policies for the management of the paediatric bleeding patient and concentrates on the communication around the use of blood components for the resuscitation of victims of major trauma. The guideline assumes that all necessary measures to identify and control bleeding sites are on-going, and effort must be directed at preventing hypothermia using fluid warmers and external warming devices (such as a Bair Hugger).

References to guidelines from the British Standards in Haematology (BSH) and NICE have been made in line with their recommendations.

Key Points

- In clinical practice, haemodynamic changes compatible with hypovolaemia accompanying evidence or suspicion of serious haemorrhage are the usual triggers for massive haemorrhage
- Approximate patient weight in kg can be estimated from the formulae below or using the APLS aide-memoire
    - <1yr (0.5 x age in months) +4
    - 1-5yrs (2 x age in years) +8
    - >5yrs (3 x age in years) +7

Communication with the Blood Bank Laboratory

Early communication with the Blood Bank Laboratory is essential for timely provision of blood.

Give patient details and request the Major Haemorrhage Pack.

- Ensure **two** correctly labelled blood samples for Group & Save / Crossmatch are sent as soon as possible. *Incorrectly labelled samples will lead to a delay in the provision of blood and blood components*
- For infants less than 4 months old the blood bank will require a maternal blood sample which should include the following information:
    - Mother's first and last name, date of birth, and NHS number
    - Date and time of sample
    - Name and signature of person taking the sample
    - Make sure blood request form is completed with mother and child details so the two samples can be linked. Do not label samples 'mother of' or 'baby of'. Each sample must be fully labelled to meet minimum labelling requirements for transfusion.
    - **The 2-sample rule does not routinely apply to maternal blood samples.**

Administer red cells and FFP in a 1:1 ratio in 10ml/kg aliquots

Liaise with laboratory staff regarding the provision of the most appropriate blood components:

Red Cells	• Emergency O RhD negative • O RhD positive may be issued for male patients • Un-crossmatched or group specific • Crossmatched
Fresh frozen plasma (FFP)	• FFP issued MBFFP (methylene blue treated FFP) • Allow time for thawing of FFP
Platelets	• Standard dose is 10ml/kg • Be aware of stock levels within the hospital
Cryoprecipitate	• Aim to maintain fibrinogen levels >1.5 g/l • Allow time for thawing of cryoprecipitate

IV tranexamic acid 15mg/kg (max 1g) should be given ideally within the first hour and should not be commenced after 3 hours. This is followed by a maintenance dose of 2mg/kg/hour over the next 8 hours. Consider use of **IV calcium** at the same time as tranexamic acid if ionised calcium <1.0 mmol/litre.

Do not wait for blood results but be guided by the clinical assessment of the on-going need for blood component resuscitation.

Transfer of blood products and components between hospitals

- No special arrangements are required for blood products already prescribed, checked and being administered to the patient prior to transfer, these can be continued.
- Contact the Blood Bank Laboratory and request blood for transfer; confirm who will organise appropriate documentation and storage requirements.
- Blood products and components being transferred with a patient to another hospital must:
    - be packaged appropriately in a blood transport box to maintain the cold chain.
    - have transit documentation completed (appendix).
    - have a transport label on the outside of the transfer box.

- Any unused blood products that have arrived in the clinical area should not be sent on with the patient without being properly packaged by the Blood Bank Laboratory staff.
- If packaged blood products are required for transfusion, determine that the products have been stored correctly, the box remains within the expiry limits and still feels cold. Remove one unit at a time only. Ensure the box is opened and closed as quickly as possible. Ensure the box lid is replaced properly. Record the time each unit is removed from the box on the blood transfer documentation. Once the box is opened then transfusion of all contents, if required, must be completed within 4 hours.
- When completing a transfusion of blood products that originated in the referring unit, the empty bag must be spigotted and sent to the Blood Bank Laboratory at the receiving unit. Call the Blood Bank Laboratory to explain the situation so they can liaise with colleagues at the referring hospital and close the loop.
- If blood products are not required for transfusion ensure the blood products are put in the Blood Bank Laboratory fridge as soon as possible. Liaise with the Blood Bank Laboratory.

See Appendix 1 – additional resources
1a. Management of massive haemorrhage flow chart
1b. Transfusion transfer documentation
1c. Massive haemorrhage – additional information

6. Emergency anaesthesia and airway management

Most paediatric airways are straightforward to manage, and intubation is easy after neuromuscular blockade; however airway management in major trauma may be very challenging.

Difficulties may be increased by

- The unfamiliar environment
- Time pressure
- Multiple simultaneous interventions
- C spine stabilisation
- Trauma to face and neck with oedema and soiling of the airway with blood
- Agitated uncooperative child due to pain and hypoxaemia

Have a low threshold for seeking senior assistance. If difficulty is anticipated either due to underlying difficult anatomy or to airway trauma, and time allows, get senior anaesthetic and ENT assistance and assemble equipment before attempting to secure the airway.

Oro-tracheal rapid sequence induction is the method of choice for securing the airway in paediatric major trauma, however effective pre-oxygenation may not be possible. Young children desaturate rapidly and this may be exacerbated by major trauma leading to a significant risk of hypoxia during intubation. **Gentle** ventilation with 100% O_2 post induction prior to intubation will allow for optimal relaxation and oxygenation prior to intubation.

Indications for **IMMEDIATE** intubation

- Airway obstruction
- Airway protection
- GCS<8
- Traumatic cardiac arrest

Consider **EARLY** intubation

- Hypoventilation
- Airway protection
- Burns, smoke inhalation
- Persistent hypoxaemia
- Haemorrhagic shock
- Severely injured child needing intervention in theatre/radiology
- To perform therapeutic and diagnostic procedures if uncooperative despite analgesia
- Stabilisation prior to transfer/retrieval
- Respiratory distress
- Cervical cord injury with evidence of respiratory insufficiency

Induction drugs

The drugs used for induction and their quantities will be based upon clinical assessment and the practitioner's experience of their use. **This must include consideration of drugs recently given for analgesia and procedural sedation** in the pre-hospital phase of care.
It is strongly recommended that ketamine is used as the induction agent of choice in major trauma. It provides relative haemodynamic stability and a wide therapeutic margin (10-20% context specific overdose is unlikely to cause problems).

The following regimes are strongly recommended:

Standard 3:2:1

Fentanyl **3 microgram/kg**, Ketamine **2mg/kg** and Rocuronium **1mg/kg**

Hypovolaemic 1:1:1

Fentanyl **1 microgram/kg**, Ketamine **1mg/kg** and Rocuronium **1mg/kg**

If **severe hypovolaemia** is suspected fentanyl may be omitted. In some very exceptional circumstances it may be appropriate to administer a paralysing agent alone.

Top tips

- Remove the front of the collar for intubation
- Have a low threshold for using a bougie or a stylet to minimise neck movement
- Consider a cuffed tracheal tube if there is airway soiling or the need for high pressure ventilation
- Use an uncut tube in burns and facial trauma
- Gastric distension can significantly compromise ventilation. Decompress the stomach with an orogastric or nasogastric tube
- Post intubation ventilate to normocarbia of 4.5 - 5kPa. Don't rely on the absolute value of EtCO2, check a blood gas

See Appendix 2 – Airway Algorithms including Surgical Airway

2a. Paediatric emergency anaesthesia - drugs
2b. Paediatric trauma intubation checklist
2c. Paediatric RSI kit dump
2d. Emergency anaesthesia flow chart including failed intubation / failed oxygenation
2e. Needle cricothyroidotomy
2f. Surgical cricothryoidotomy

7. Chest injuries including chest drains, penetrating cardiac injuries and resuscitative thoracotomy

Chest drains

Chest trauma is common.
Only a minority of patients with chest trauma require surgical intervention.
Insertion of an appropriately sized correctly positioned chest drain is the only procedure required in the management of most chest injuries.

Indications:

- **Potentially life-threatening conditions identified in the primary survey requiring a chest drain:**
    - **Tension pneumothorax**
    - **Open pneumothorax, in conjunction with closing / covering the open wound**
    - **Massive haemothorax**

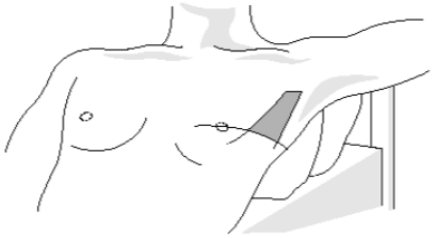
- **Other indications**:
    - 'Large' simple pneumothorax not under clinical tension
    - Any pneumothorax in a haemodynamically unstable patient
    - Any pneumothorax in a child who is intubated for transfer to another hospital
    - Bilateral pneumothoraces
    - Large pleural effusions
    - Formal drain after thoracostomy (best to insert drain in separate site)

Cautions:

- The presence of surgical emphysema **is not** an indication for a chest drain if no pneumothorax can be identified on imaging
    - Consider a chest drain in worsening surgical emphysema
- The identification of an asymptomatic pneumothorax on a Trauma CT scan is **not** an indication for a chest drain in an otherwise stable patient
- The presence of needle catheters in the 2nd intercostal space, mid-clavicular line that have been inserted prior to arrival in A&E does not mandate the insertion of a chest drain unless clinically indicated
- There is no evidence to support **not** inserting a chest drain in a patient with a symptomatic large haemothorax, for fear of releasing the tamponade effect. Large effusions usually cause tension, and these patients have a "B" problem due to their lung collapse as well as a "C" problem

- It is **not** mandatory to insert a chest drain in a patient with an asymptomatic pneumothorax who is to be intubated and ventilated for theatre, although awareness of the presence of a pneumothorax is essential.
- It **is** mandatory to insert a chest drain in a patient with pneumothorax who is intubated for transfer.

Procedure



- Chest drain size is dependent on age/size of the child, but a 20Fr chest drain should be sufficient in most situations. In the trauma situation, small bore Seldinger drains should be avoided unless there is a specific indication after discussion with an appropriate specialist team
- Insertion is in the triangle of safety, as per ATLS/APLS guidelines on chest drain insertion. If a small bore Seldinger drain is considered appropriate it can be inserted at the same site.
    - Position patient if feasible
    - In a conscious, alert child, give sufficient local anaesthetic & enough time to work
    - Assess length of drain needed - insertion site to apex or base depending upon need
    - 5th intercostal space + anterior axillary line
    - Incision through skin and subcutaneous tissues to intercostal muscles
    - Blunt dissection with large clip + “above rib below” to avoid intercostal nerves and vessels
    - Insert drain to required length, angling drain posteriorly in most cases
    - Ensure all holes are within chest cavity
    - Secure drain (suture or tape)
    - Connect to underwater seal
    - Place simple dressing around drain site
    - Obtain a CXR to confirm position, unless going for chest CT

- **Cautions:**
    - Beware the rare patient with chest scars and previous chest surgery - adhesion risk
    - A ruptured left hemidiaphragm and an intrathoracic stomach can mimic a pneumothorax
    - A ruptured right hemidiaphragm and an intrathoracic liver can mimic an effusion
    - **NEVER routinely clamp a chest drain** – extreme care and senior decision making must be taken in the exceptional circumstance where clamping is considered

- **Note:**
    - Underwater seal drains are not recommended for transport – a Heimlich valve, pneumostat or dry chest drainage system is preferred

For further guidance on analgesia (other than local anaesthetic) refer here.

Management of the patient with a chest drain

- **What to measure:**
  - Swinging or not
  - Presence of an air leak
    - Constant
    - On expiration
    - On coughing
  - Fluid
    - Volume
    - Colour / consistency
- **When to measure:**
  - Hourly
  - 24-hour total
- **Inspect the drain site**
- **Suction:**
  - Avoid suction on chest drains unless advised by paediatric surgery
- **Cautions:**
  - In most trauma situations the effusion will be haemorrhagic
  - Involve early the paediatric surgical team involved in the patient's care, or if in a Trauma Unit discuss with a paediatric surgeon at the MTC, if there is
    - persistent air leak
    - persistent blood loss after initial drain insertion
    - effusion suggestive of gastric contents (which may indicate oesophageal rupture or a ruptured hemidiaphragm with an intragastric drain)

When to remove a chest drain

- When the reason for the chest drain insertion is gone, the drain should be gone
- When the drain has stopped draining it is no longer needed
- In a pneumothorax, there should be no air leak for 24 hours
- Usually there is no need for a stitch to close the drain hole
- Chest drain removal is usually a two-person job – one person to remove the drain and the other to cover the wound.
  - There is some evidence (following elective thoracic surgery) that removing the drain at the end of full expiration leads to a lower incidence of non-clinically significant pneumothorax. This can be difficult in children
- It is **not mandatory** to obtain a CXR following drain removal, if the patient remains well and there are no concerns on auscultation. If in any doubt, a CXR is indicated
- **Caution:**
  - Occasionally drains stop working because they are blocked, kinked or dislodged
  - Assess patient clinically +/- CXR if this suspected

Resuscitative thoracotomy

Regardless of their location with the Y+H trauma network, immediate resuscitative thoracotomy should be undertaken for patients in traumatic cardiac arrest, with suspected tamponade or exsanguination, in a survivable window.

Clinical evaluation should focus on aetiology of traumatic cardiac arrest and presenting cardiac rhythm rather than duration of cardiac arrest – this is often difficult to define.

This guidance assumes the patient is of teenage maturity or post pubertal. The evidence base for thoracotomy in younger children is very limited but should be considered on a case-by-case basis.

Indications

Cardiac Tamponade

Suspected Tamponade*
AND
Loss of signs of life within 15 minutes**
OR
Organised electrical cardiac activity***

Exsanguination

Non-compressible intrathoracic or subdiaphragmatic haemorrhage
AND
Organised electrical cardiac activity***

* Suspected Tamponade:
- Penetrating trauma to thorax, supraclavicular region, or epigastrium
- Blunt trauma to the chest with signs & symptoms of tamponade (ultrasound confirmed, pulsus paradoxus, or Beck's triad (raised JVP, muffled heart sounds, HD instability))

** Signs of life include a palpable pulse, spontaneous respiration, and response to pain

***Organised electrical activity includes narrow complex PEA (slow or fast), but not wide complex agonal or asystolic rhythms

Features associated with good clinical outcomes

Tamponade aetiology
Short duration of traumatic cardiac arrest (<5 minutes)

Procedure

Be bold, don't hesitate - aim to enter pericardium in <90 seconds

Simple kit - scalpel, Spencer Wells forceps, tuff cut scissors, Gigli saw (not essential)

Beware of high risk of sharps injury

Concurrent actions – venous access, volume resuscitation, tranexamic acid, monitoring

- **Supine** – arms as far from chest as possible, crucifix position if feasible.
- **Bilateral antero-lateral open thoracostomies (same interspace)** pause ventilation to avoid lung injury. STOP and reassess afterwards- was this a tension pneumothorax?
- **Join two thoracostomies** – scalpel to make skin incision, then cut through intercostal muscles with tuff cut scissors. Follow rib spaces like an underwired bra - NOT straight across. Cut the sternum with tuff cuts or Gigli Saw.
- **Always do a clamshell**
- **Divide sterno-pericardial fascia** with fingers. Hold chest open with rib spreaders or manually with gauze over sharp edges.
- **Open pericardium with an inverted T incision in all cases** - avoid phrenic nerves. Evacuate any clot and inspect heart.
- **Descending aortic compression** – immediately for subdiaphragmatic exsanguination but also employ early for tamponade cases. Hand through left chest, compression against spinal column with thumb or fingers.

Cardiac tamponade cases:

- If the heart begins to beat spontaneously - Close wounds rapidly (finger, suture, staples)
- If heart is beating but with reduced output - Close wounds, internal massage and volume resuscitation / inotropes
- If heart is in asystole - Attempt to flick pericardium to restart, internal massage, volume resuscitation

Wound management:

- Small wounds: finger / gauze occlusion
- Large wounds: suture/staples, consider foley catheter (will reduce cardiac chamber volume)
- Multiple wounds: not futile but consider survivability

Exsanguination cases PRIORITISE:

- Volume resuscitation
- Internal massage if indicated
- Aortic root resuscitation (maximising aortic root perfusion and hence coronary arterial pressure).

- **Internal massage –** 2 handed technique, one behind heart. Milk blood up from apex. Do not allow heart to become vertically positioned as great vessels will become kinked.
- **Lung wounds –** direct pressure with fingers or grasp a lobe. Consider a clamp or 'slooping' by tying foley catheter around hilum.
- **Defibrillate -** if shockable rhythm with internal paddles starting at 10 joules.
- **Volume resuscitation** – use massive transfusion pack, ideally via large bore central venous access.

If ROSC is achieved:

- Patient will require consultant-led care from anaesthetics and thoracic surgery.
- Seek MTC advice / patient transfer / staff transfer
- Control internal mammary arterial haemorrhage with artery clips
- Consider sedation and neuromuscular blockade

Useful links

The Procedure of ED Thoracotomy (emcrit.org)

http://www.trauma.org/archive/atlas/clamshell.html

Emergency thoracotomy: "how to do it" | Emergency Medicine Journal (bmj.com)

Clamshell incision versus left anterolateral thoracotomy. Which one is faster when performing a resuscitative thoracotomy? The tortoise and the hare revisited - PubMed (nih.gov)

trauma_unit_resuscitative_thoracotomy_guidelines.pdf (wymtn.com)

8. Abdominal injuries

Abdominal injuries often co-exist with chest and pelvic injuries.
More children in Yorkshire & Humber suffer blunt force trauma through motor vehicle collisions, falls and assaults, than penetrating trauma. The management guidance differs between blunt and penetrating mechanisms of injury, so these will be considered separately.

Blunt Injury

Clinical assessment

- The patient will be assessed by the trauma team in line with Trauma Management principles. Abdominal examination should be included within "C" as a potential site of bleeding. Patients in shock and suspected to have intra-abdominal injury (including at time of pre-alert) need immediate transfer to the Paediatric MTC. **This should be ED to ED and does not need discussion with specialities within the MTC as automatic acceptance is Network standard.**

- Any patients not meeting criteria for immediate transfer should be discussed early with:
    - MTC: the on call Paediatric Surgical Consultant or Middle Grade. Alert the interventional radiologist on-call where appropriate.
    - TU: the on call General Surgical Consultant.
- Ensure O Negative blood will be available and warn that the Massive Haemorrhage Protocol may be activated (Section 5).
- **Inspection:** Abdominal wall bruising is highly indicative of intra-abdominal injury. This is infrequently associated with abdominal distension. Swallowed air is the most common cause of distension - insert a gastric tube. New and progressive abdominal distension in a shocked patient suggests exsanguinating intra-abdominal haemorrhage.
- **Palpation:** Tenderness on examination should prompt further investigation but examination in a distressed child is challenging and may be compromised by other distracting injuries or reduced level of consciousness. Absence of clinical signs does not exclude injury.
- **Percussion and auscultation**: Add little to the examination. The presence or absence of bowel sounds has no diagnostic value.
- Repeated clinical assessment is valuable

Investigation

- **Bloods:** FBC, U&E, clotting, venous gas and cross-match (with activation of Massive Haemorrhage Protocol if appropriate) should be taken for all significantly injured patients. Consider a pregnancy test, if relevant.
- **Ultrasound:** In the acute paediatric trauma setting there is no role for ultrasound outside of assisting in interventional procedures.
- **CT scan:** Contrast-enhanced CT is the modality of choice for the assessment of acute traumatic intra-abdominal injury. Where there is concern for significant intra-abdominal injury, all patients should undergo a CT scan using appropriate paediatric imaging protocols (Section 17) unless there is rapid haemodynamic deterioration that requires immediate transfer to theatre. CT is best performed at the Major Trauma Centre (MTC), however for some less severe injuries the CT may be performed at the Trauma Unit. The findings will need to be discussed with the Paediatric Surgical Consultant at the MTC.

Management (see Appendix 3a)

The guidance below covers expected management at the Major Trauma Centre. At a Trauma Unit management may be limited by the available resources. When the treatment necessary exceeds the TUs capabilities the patient will require transfer to the MTC. The MTC can be contacted for advice at any time.

- The management of patients with unresponsive or transiently responding shock/hypotension is challenging. Early consideration must be given to blood transfusion in line with the Massive Haemorrhage Protocol. Any patient considered to have significant on going intra-abdominal

bleeding requires rapid transfer to theatre for resuscitation and potential damage control surgery - laparotomy, pelvic stabilization, thoracotomy etc.

- Patients whose shock is not rapidly deteriorating should have a trauma or targeted CT scan in line with the Y&H guidance on imaging in paediatric trauma.
- Patients with radiological evidence of ongoing bleeding from solid organs (spleen, kidney, liver) must be discussed with the Consultant Paediatric Surgeon, Consultant Paediatric Radiologist/ Interventional Radiologist, Consultant Paediatric Intensivist and Consultant Paediatric Anaesthetist to decide the optimal method and location of haemorrhage control.
- Patients with radiological evidence of pseudoaneurysm rather than free, active bleeding from the spleen, liver or kidney must be discussed with the Consultant Paediatric Surgeon and Consultant Paediatric Radiologist/ Interventional Radiologist with a view to angio-embolisation. This may require Vascular Intervention in Leeds.
- Patients with solid organ (spleen, kidney, liver) injury but no evidence of ongoing bleeding or pseudoaneurysm must be discussed with the Consultant Paediatric Surgeon. Non-operative management is superior in such cases. This should only be undertaken in a specialist paediatric high dependency setting, with appropriate staff and equipment should there be deterioration. It is appropriate to transfer these patients early to the MTC, rather than transfer on deterioration. The patient must be adequately resuscitated to correct hypoperfusion. In a minority of patients due to the increase in perfusion pressure, bleeding may recur.
- During non-operative treatment regular clinical examinations and hemoglobin measurements must be undertaken. If re-bleeding is suspected (progressive shock and / or falling hemoglobin) transfer to theatre or further CT angiography is required. If confirmed, then angio-embolisation or operative control of bleeding is required. Increasing abdominal pain, tenderness, inflammatory markers or deranged liver function tests may be the result of a missed hollow viscus injury, pancreatic injury or a local complication of solid organ injury e.g. biliary peritonitis. Mesenteric bleeding can lead to slowly developing local intestinal ischaemia and delayed intestinal perforation as well as the risk of ongoing haemorrhage. Further CT imaging is indicated to attempt to identify the underlying problem.
- Patients with Grade IV or more splenic or hepatic injuries undergoing non-operative management should be considered for angiography as a proportion will reveal significant vascular injury which if treated should reduce the risk of re-bleeding. This may require Vascular Intervention in Leeds. For more detail on the solid organ injury grading system see https://www.wymtn.com/uploads/5/1/8/9/51899421/abdominal_trauma_-_paediatrics.pdf (Appx 1-3).
- Patients with evidence of hollow viscus injury, mesenteric injury or diaphragmatic injury on the initial CT will almost certainly require laparotomy and should be discussed with the Consultant Paediatric Surgeon.
- The Embrace conferencing system allows TU and MTC to talk directly to each other and can facilitate discussion between multiple clinicians. Embrace Embrace - Sheffield Children's NHS Foundation Trust (sheffieldchildrens.nhs.uk) can also give advice on transfers if needed. **For immediate transfer procedure see here.**

Penetrating Injury

Background

- Paediatric penetrating injuries are very uncommon. Within the trauma network, gunshot wounds are very rare but stabbing and impalements do occur. The mechanism of wounding needs to be established as it strongly influences management decisions. Adult patients suffering stab injury are less likely to require laparotomy (25-33%) than those suffering gunshot injury (80-95%). Note, 55-60% of patients with any stab wound that has entered the peritoneum have hypovolemic shock, peritonitis or bowel / omental evisceration and require a laparotomy. In the remainder, 50% will eventually require operation if observed. Most patients with abdominal gunshot wounds have significant intraperitoneal injury and therefore justify laparotomy.
- Clinicians have a responsibility to inform the police if a patient attends the Emergency Department with a knife or gunshot wound after an assault but demographic information should, in the first instance, only be shared with the patient's consent. Reporting is the responsibility of the ED consultant in charge. Further information can be found at https://www.gmc-uk.org/ethical-guidance/ethical-guidance-for-doctors/confidentiality---reporting-gunshot-and-knife-wounds

Clinical assessment

- The patient must be assessed by the trauma team in line with Trauma Management Principles. Abdominal examination should be included within "C" as a potential site of bleeding. As with blunt injury, patients in shock with penetrating chest and / or abdominal injury need immediate transfer to the Paediatric MTC. **This should be ED to ED and does not need discussion with specialities within the MTC as automatic acceptance is Network standard.**
- Any patients not meeting criteria for immediate transfer should be discussed early with:
    - MTC: the on call Paediatric Surgical Consultant or Middle Grade. Alert the interventional radiologist on-call where appropriate.
    - TU: the on call General Surgical Consultant.
- Ensure O Negative blood will be available and warn that the Massive Haemorrhage Protocol may be activated.

- **Inspection:** Do not exclude significant injury on the basis of perceived depth or direction injury from the entry point of the wound; few patients are in the anatomical position at the time of injury. Unless the patient requires an emergency department thoracotomy, the patient must be log rolled to identify all injuries. Particular care should be taken to inspect the axillae and perineum as wounds in these sites can be missed. Skin wounds should be marked with radio opaque markers e.g. closed paper clip taped to anterior wounds and opened paper clip to posterior wounds. Never remove protruding weapon or foreign body. Abdominal distension may be a sign of significant intra-abdominal bleeding, but a significant volume of blood can collect without undue distension.

- **Palpation:** Tenderness around the wound is to be expected but progressive pain and tenderness remote from the initial wound suggests intra peritoneal hollow viscus injury. As with blunt injury, the reliability of clinical examination will be reduced when there are remote but distracting injuries or reduced consciousness (head injury, intoxication, sedating medication, spinal cord injury).
- **Percussion and auscultation:** Add little to the examination. The presence or absence of bowel sounds has no diagnostic value.

Investigation

- **Bloods:** FBC, U&E, clotting, venous gas and cross-match (with activation of Massive Haemorrhage Protocol if appropriate) should be taken for all significantly injured patients. Consider a pregnancy test, if relevant.
- **Ultrasound:** FAST scan has no role in the exclusion of hollow viscus injury.
- **CT scan:** discussed in the management section below.

Management of penetrating injuries.

The guidance below covers expected management at the Major Trauma Centre. At a Trauma Unit management may be limited by the available resources. When the treatment necessary exceeds the TUs capabilities the patient will require transfer to the MTC. The MTC can be contacted for advice at any time.

Management of stab wounds (see Appendix 3b)

- For patients with penetrating injury, balanced resuscitation should be utilized unless contraindicated (traumatic brain injury).

- The management of patients with unresponsive or transiently responding shock/hypotension is challenging. Early consideration must be given to blood transfusion in the Massive Haemorrhage Protocol. Any patient considered to have significant ongoing intra-abdominal bleeding requires rapid transfer to theatre for resuscitation and potential damage control surgery - laparotomy, pelvic stabilization, thoracotomy etc.
- Other causes of shock need to be considered e.g. bleeding (chest, limbs, bleeding from wounds), tension pneumothorax and cardiac tamponade. Clearly, patients with multiple wounds can have life threatening pathology in more than one body cavity.
- Patients with foreign bodies (eg. knives) protruding from the abdomen require these to be removed in the operating theatre with the abdomen open if there is any concern that they may have entered the peritoneum. Preoperative CT scan is likely to be degraded by artefact but may be considered if findings would influence surgical approach.
- Patients without overt shock but with clinical signs of peritonitis or bowel / omental evisceration require a laparotomy (bowel evisceration is associated with a 75% risk of bowel perforation). A preoperative CT scan may be undertaken but the trauma scan is poor at detecting fresh hollow organ injury.

- Patients without overt shock but with an unreliable examination e.g. brain injury, spinal cord injury, intoxication or sedating medication, should have further investigation with a CT scan or undergo exploratory laparotomy / laparoscopy.
  Patients who are conscious, cooperative and can concentrate and with no signs of peritonitis or diffuse abdominal tenderness (away from the wounding site) may be initially managed non-operatively. A CT scan should be performed to help quantify the depth of injury. Repeated / serial examination preferably by the same experienced surgeon should be undertaken. At hand over, ideally both surgeons should examine the patient together and agree on the clinical findings. Any injury is likely to reveal itself within 24 hours or so after this time.
- Stab wounds can be classified as anterior (between the anterior axillary lines), flank (between anterior and posterior axillary lines) and posterior (posterior to posterior axillary line). In general, one third of anterior wounds do not penetrate the peritoneum. One third penetrate the peritoneum but no not require intervention, and the remaining third penetrate the peritoneum and require surgical repair. Anterior abdominal wounds may be explored under local anaesthetic within the emergency department if the child is older and compliant or under a general anaesthetic in theatre. If the wound extends deep to the anterior fascia then the chance of intraperitoneal hollow viscus perforation is increased although not definite. Patients with posterior fascial penetration proceed to theatre to laparotomy / laparoscopy. Hollow viscus injury can be difficult to detect even at laparotomy. Exclusion of visceral injury by laparoscopy should only be performed by those with significant experience in such cases.
- Exploration of flank and posterior wounds is rarely indicated. In the absence of a need for immediate laparotomy (shock or generalized peritonitis), a CT scan helps to determine depth of injury.
- Thoraco-abdominal injuries can present a diagnostic dilemma as penetrating wounds between the nipples and costal margin may damage structures within the chest cavity, within the peritoneal cavity and make a hole in the intervening diaphragm.
    - Patients with unresponsive or transiently responding shock and considered to have ongoing abdominal or thoracic bleeding require rapid chest drain insertion and transfer to theatre for laparotomy and any other surgery required to control bleeding.
    - For patients without overt shock, a CT scan will give some indication of the trajectory of the wound although may not detect incised wounds of the diaphragm. If concern regarding diaphragmatic injury persists, then a laparoscopy/laparotomy should be performed. If an injury is detected, then the defect should be repaired, and visceral injury excluded. Both diaphragmatic repair and exclusion of visceral injury are possible laparoscopically but only by those with appropriate skills and experience.

Management of low velocity (hand gun / shotgun) gunshot wounds (see Appendix 3c)

- These are extremely rare in the paediatric age range and management should follow adult guidelines.

- Patients with abdominal gunshot wounds have a very high chance of intraperitoneal injury and must undergo laparotomy to exclude injury rather than define it. Importantly projectiles may move in non-linear planes and ricochet. Few patients are shot in the anatomical position.
- Patients with unresponsive or transiently responding shock require immediate laparotomy. Those without overt shock may undergo a CT scan to guide surgical planning and identify those few patients with tangential injuries. Close range shot gun injuries are locally destructive and likely to penetrate the peritoneum mandating laparotomy. For those delivered at distance, CT scanning may demonstrate pellet penetration deep to peritoneum although scatter may limit image quality.

Management of high velocity and ballistic injuries

- The experiences from Manchester and London highlight the need for consideration of management of high velocity and ballistic injuries. There is very little civilian experience in such management and expert advice is best sought on the management of such patients. Key learning points from the Manchester are
    1. The importance of CT scanning to identify shrapnel injuries
    2. The importance of considering the need for prophylaxis for possible blood borne infection (see latest Public Health England and NHS England guidance)
    3. In the event of a Mass Casualty Incident, different rules may apply, and staff in all hospitals receiving paediatric major trauma patients should be familiar with their own Major Incident Policy.

Venous Thromboembolic (VTE) prophylaxis in patients with abdominal injury

- Mechanical prophylaxis eg. TED stockings can be used for all patients where an appropriate size exists, unless precluded by lower limb injury.
- Pharmacological prophylaxis with LMWH should be commenced when the risk of further bleeding becomes less than the risk of VTE - usually at 18:00 following the day of surgery and if there is no coagulopathy (normal INR and APTT).

9. Severe pelvic fractures and urogenital injury

Pelvic fractures

Referral pathway

- Patients with suspected pelvic fractures with signs of haemodynamic instability should be transported directly to the Major Trauma Centre (MTC).
- If the patient presents to a Trauma Unit then resuscitation should be commenced followed by immediate transfer to the MTC for definitive treatment.
- The Major Trauma Networks have agreed an **immediate transfer** policy regarding patient referrals to the Major Trauma Centre (see **Section 3**).

Pelvic binders

- Apply a pelvic binder when there is a suspected active bleeding from a pelvic fracture. This should be applied pre-hospital.
- The pelvic binder should remain in-situ during surgery and this should not be removed for a post binder pelvic X-ray until the patient is haemodynamically stable.
- A well applied pelvic binder can mask a catastrophic pelvic ring injury even in the presence of a 'negative' CT scan. All polytrauma patients require a post-binder X-ray after resuscitation.
- Each trauma network must have a protocol for binder removal but, ideally, it should be removed within 24-hours of injury.

Management of massive haemorrhage – see also Section 5

- In the presence of haemodynamic instability, patients should be urgently resuscitated using blood products according to massive haemorrhage protocol.
- All patients require IV Tranexamic Acid as soon as possible and ideally within an hour of injury

Radiology – see also Section 17

- Patients with suspected pelvic fractures from high-energy trauma should have an urgent CT scan with contrast including head, chest, abdomen and pelvis.
- All patients with blunt polytrauma undergoing damage control laparotomy should have imaging of the pelvis before surgery (X-ray or CT).

Surgical and interventional management

- Major Trauma Centres must have a clear protocol in place for managing active bleeding from the pelvis in patients who do not respond to resuscitation. This may be managed by surgical packing of the pelvis or interventional radiology with selective embolization of active arterial bleeding vessels.
- External fixation should be considered for temporary mechanical stabilisation when early definitive surgery cannot be performed.

- In displaced vertical shear fractures, traction should be considered when early definitive surgery cannot be performed.
- Reconstruction of the pelvic ring should occur within 72 hours of the stabilisation of the patient's physiological state if associated injuries allow.

Open pelvic fractures

- Open pelvic fractures associated with wounds to the lower abdomen, groin, buttocks, perineum, anus (including sphincters) and rectum require urgent assessment by a consultant paediatric general or colorectal surgeon, and wound debridement.
- Clinically and/or radiologically proven or suspected injuries to the anus and/or rectum may require formation of a defunctioning stoma.
- Nursing care of wounds to the perineum or buttocks may also require a defunctioning stoma, although this is unlikely to be necessary for open pelvic fractures associated with wounds to the groin or lower abdomen alone.

Thromboprophylaxis

- The Major Trauma Unit should have a policy in place for thromboprophylaxis for patients with pelvic fractures.

Urogenital trauma

Urethral injuries in children tend to follow the same mechanism of injury as in adults. Straddle pelvic fractures are more common in children. Children with urogenital injury will need to be managed in a Paediatric Major Trauma Centre.

During the initial exploratory survey / secondary survey

- Examine the external urethral meatus for evidence of injury or the presence of blood.
- If a transurethral bladder catheter is in place, examine the tube for blood.
- Look at the flanks, abdomen, perineum and the external genitals for evidence of haematomas, ecchymosis and external injuries.

All patients with haematuria, blood discharge from the urethral meatus, dysuria or suspicious features in the history (local hematoma, concomitant injuries, mechanism of injury) have an increased risk of genitourinary injuries and should be given a focussed diagnostic work-up of the kidney and/or the efferent urinary tract. Insertion of a urethral catheter should only be attempted by a paediatric urologist or senior doctor.

Transurethral catheter insertion

A single gentle attempt of passing a standard transurethral bladder catheter can be attempted by an experienced doctor, even if the clinical or CT findings suggest a urethral injury.

- A 6- 8F soft silicone catheter and sterile technique should be used (the size should be adjusted appropriately for children). If the catheter has a stylet, this should be withdrawn approximately 1 inch proximal to the balloon.
- If the catheter passes and clear urine comes through, then inflate the balloon.
- If the catheter passes but blood-stained urine comes through, then again inflate the balloon.
- If the catheter will not pass or passes and frank blood is drained then DO NOT inflate the balloon, withdraw the catheter and perform retrograde urethrogram. Contact a paediatric urologist
- If the insertion of standard transurethral bladder catheter fails, a retrograde urethrogram and the insertion of a suprapubic catheter (SPC) should follow by a paediatric urologist.
- In the case of circulatory instability that does not permit initial diagnostic tests and if it is impossible to insert a transurethral bladder catheter, a suprapubic urinary diversion should be performed percutaneously (with ultrasound guidance if necessary) or by laparotomy (with simultaneous exploration) by a paediatric urologist.

Suprapubic Catheter (SPC)

If a urethral catheter cannot be passed, a suprapubic catheter is required. This can be inserted during emergency laparotomy, but otherwise percutaneous suprapubic catheter should be placed.
The suprapubic catheter should be placed using a Seldinger technique under ultrasound control by a doctor experienced in the use of USS guided SPC techniques:

- The bladder must be significantly filled
- The skin insertion point MUST be in the midline (through the linea alba) and should be placed 2 finger breadths (4cm) above the pubic symphysis to prevent bowel injury – with variation following consideration of patient size
- An appropriate silicone catheter or vesicostomy button should be used. This is large enough to allow blood clots to pass and avoid clot retention
- A size Ch20 dilator should be used to allow easy passage of a Ch14 catheter or button.

If the bladder cannot be identified on USS and so a percutaneous suprapubic catheter cannot be placed, this is a very difficult situation. Consultants in paediatric urology and general paediatric surgery must be involved in decision making, and open placement of the catheter +/- laparotomy should be considered.

Imaging

Diagnostic imaging should be carried out on the efferent urinary tract if one or more of the following criteria apply:

- Haematuria /bleeding from the urethral meatus or vagina / dysuria / local hematoma

CT cystogram should be performed at the time of the initial trauma scan, when there is pelvic fracture or haematuria, if the patient is stable. If not stable, the delayed cystogram either fluoroscopic or CT should be performed.
CT with contrast should be performed in the case of suspected kidney injury.

Retrograde contrast urethrogram - cystogram

Other imaging such as retrograde urethrogram and cystogram (to look for possible urethral or bladder injury) should be dealt with at the Major Trauma Centre

- Always consult a consultant paediatric urologist prior to investigation
- Discuss with a Radiology Consultant
- Sterile technique must be used and the procedure performed by an experienced clinician
- Consider parenteral antibiotics (gentamicin)

If the urethrogram is positive, decision making needs to be at the most senior level by a consultant paediatric urologist. If a suprapubic catheter is needed, suggest discussion with the pelvic and acetabular surgeons, as this will have major implications for any internal fixation.

Infection prevention

- Urine becomes contaminated with bacteria within 5 hours of passage of a urinary catheter.
- If there is a urine leak from the bladder or urethra, the pelvic fracture should be treated like an open long-bone fracture with antibiotics (Co-Amoxiclav + Gentamicin for 72 hours – seek microbiological advice if penicillin allergy) and early fracture fixation if the patient's physiology allows.

Surgical management

It is expected that urogenital injuries will be managed at the Major Trauma Centre (MTC).

Bladder Injury

- Intra-peritoneal bladder rupture requires emergency laparotomy and direct repair. It carries up to 50% mortality and should be explored with urgency by a paediatric urologist. Immediate transfer to the MTC will be required.
- Extra-peritoneal bladder rupture without involvement of the neck of the bladder can usually be conservatively treated through urethral urinary diversion, providing that there is no concurrent urethral injury. In the presence of a pelvic fracture that requires fixation, primary repair of the bladder is recommended at the same time.
- Bladder injuries identified during pelvic fracture surgery should be repaired at the same time and bladder drainage (via urethral or suprapubic catheter, as appropriate) ensured.

Urethral injury

- Complete rupture of the urethra should be treated in the emergency surgery phase by suprapubic urinary diversion and either primary or delayed urethral reconstruction by a paediatric urologist. Definitive management can be considered as soon as the patient is stabilised and life-threatening injuries have been treated.

10. Severe traumatic brain injury – also see flow chart Appendix 4a

Introduction

Severe traumatic brain injury (TBI) is the leading cause of death in children in the UK, accounting for 15% of deaths in 1-15 year olds and 25% of deaths in 5-15 year olds. The most common cause is road traffic accidents followed by falls. Abusive head trauma remains an important cause in infants.

The definition of severe TBI is a post resuscitation Glasgow Coma Sore (GCS) of 8 or less.

The **primary brain injury** may result in a combination of the following features:

- Skull fracture
- Cerebral oedema
- Subarachnoid, subdural, extradural or intracerebral haemorrhage
- Intraventricular haemorrhage +/- hydrocephalus
- Vascular injury and consequent stroke

These mechanisms all contribute to an increase in intracranial pressure (ICP). There is a significant risk of **secondary brain injury** due to raised intracranial pressure and hypoxic ischaemic insult after the primary brain injury has occurred.

Aims

The aims of management are to **prevent secondary brain injury** by the prevention of hypoxia, hypotension, and raised ICP.

In most circumstances, when severe TBI is suspected, a CT scan of the brain and cervical spine should be completed at the local Trauma Unit prior to transfer to the Major Trauma Centre (MTC). Situations may arise when the patient is best served by immediate transfer to the MTC. An example would be the child with multiple injuries who has been brought to the nearest hospital to secure the airway but then requires immediate transfer to the MTC, particularly where transfer times to the MTC are relatively short. For information on referral pathways see here.

If CT imaging identifies a time critical lesion (eg. extradural haematoma with mass effect) requiring urgent neurosurgical intervention then the patient requires rapid transfer to the paediatric neurosurgical centre by the local team. Even if the situation is not immediately time critical, the clinical situation can change quickly in severe TBI and a sense of urgency should be maintained by the treating clinicians in getting the patient safely to definitive care.

Key principles of treatment

1. Avoid hypoxia and hypotension
2. Avoid abnormal pCO_2
3. Maintain normothermia
4. Keep cervical spine immobilised
5. Keep ICP <20 mmHg*
6. Maintain adequate cerebral perfusion pressure (CPP)
7. Consider Tranexamic Acid – see Appendix 4b. Tranexamic acid algorithm

*When the child presents they will not have an ICP monitor in place, so it should be assumed that the ICP is 20mmHg and the mean arterial blood pressure (MAP) should be maintained high enough to ensure an adequate CPP.

Priorities

1. Standard c-ABC approach as per APLS / ATLS guidelines
    - **C**ontrol massive haemorrhage
    - **A**irway with cervical spine control
    - **B**reathing with ventilation support
    - **C**irculation with haemorrhage control
    - **D**isability – AVPU, posture and pupils
    - **E**xposure with temperature control

2. CT brain and cervical spine scan – aim within 30 minutes to enable identification of time critical brain injury.

3. Urgent referral to the Major Trauma Centre (MTC) stating severe TBI and whether time critical - *for contact details see flow chart*. Clinical advice can be facilitated by Embrace, but too many phone calls can introduce delays that may impact on outcomes. Children with potential time critical pathology requiring intervention will not be refused by the Major Trauma Centre, regardless of bed capacity.

4. Prepare for time critical transfer by local team. The transferring clinician should be the most senior anaesthetic / critical care clinician available. Aim to depart within 60 minutes of the CT scan if time critical. Every effort must be made not to introduce unnecessary delays in transfer to the MTC.

Airway and C-spine

- All children with a GCS 8 or less should be intubated orally and ventilated for airway protection and control of oxygenation and ventilation. Nasal intubation should be avoided because of the possibility of basal skull fracture.
- Spinal immobilization before, during and after intubation is essential. Intubation of these patients therefore requires a minimum of four appropriately skilled people (manual in-line immobilization, cricoid pressure, assistant to give drugs, and experienced intubator).
- Please refer to the section on Emergency Anaesthesia for choice of induction agent and muscle relaxant.
- Log roll should be used for all turns and moves to protect the cervical, thoracic and lumbar spine.
- In unconscious children, immobilisation should be with a properly fitting collar, blocks and tape. If a properly fitting collar is not available then blocks or rolled blankets should be used to provide an immobilisation device.
- Use a vacuum mattress for transport to CT scan and to the MTC if one is available. A scoop stretcher is a suitable device for transfer, although a vacuum mattress is preferable. Use of hard spinal extrication boards should be avoided.

Ventilation and oxygenation

- Anaesthesia should be maintained either with morphine and midazolam infusions, or Propofol infusion (which is safe to use as short-term anaesthesia in children who are haemodynamically stable). Muscle relaxation should be maintained with either repeated boluses or an infusion of rocuronium or atracurium.
- For general guidance on drug dosages for induction and maintenance of anaesthesia in critically ill children please refer to the Embrace drug chart. Embrace - Sheffield Children's NHS Foundation Trust (sheffieldchildrens.nhs.uk)
- All patients must have continuous oxygen saturation and end-tidal carbon dioxide (etCO2) monitoring.
- Patients should be ventilated to an etCO2 level that correlates to a blood carbon dioxide level (PaCO2) of 4.5-5.3 kPa. Blood samples for blood gas analysis may be venous, capillary or arterial.
- Provide oxygen to maintain saturations >95% or an arterial PaO2 >13kPa.
- Ventilate all patients with positive end expiratory pressure (PEEP) of at least 5 cmH2O, and peak inspiratory pressure (PIP) to achieve tidal volume of 6-7 ml/kg.

Circulation

- Every patient should have a minimum of two secure, large bore points of IV access.
- Blood should be taken for cross match, blood sugar, urea and electrolytes, full blood count, and clotting.
- Treat hypotension aggressively - hypotension is the biggest cause of ischaemic secondary brain injury. Maintain mean arterial blood pressure (MAP) to ensure adequate cerebral perfusion pressure.

Age	MAP
<1 year	>60
1-2 years	>65
3-5 years	>70
6-10 years	>75
>10 years	>80

- **Do not delay CT or time critical transfer for insertion of central and arterial access**
- Consider resuscitation with blood products early in haemorrhagic shock (see massive haemorrhage guideline).
- Consider Tranexamic Acid – see Appendix 4b. Tranexamic acid algorithm
- If cardiovascularly unstable despite fluid resuscitation, it is vital to look for sites of significant blood loss – blood on the floor (external haemorrhage), chest injury, abdominal injury, pelvic injury or femoral fracture. In infants with an open fontanelle, intracranial haemorrhage can cause life threatening hypovolaemia. Some children will need to be transferred to the MTC to manage bleeding. In the situation of uncontrolled blood loss, discussion with the regional major trauma centre is advised. Please see Section 3 for contact details.
- Some children with isolated TBI need vasoactive drug support to maintain their target blood pressure in the specified range. If the patient only has peripheral access, then use dopamine to maintain the target blood pressure. If the patient has central access, then use noradrenaline to maintain the target blood pressure.
- All patients should have a urinary catheter placed to prevent urinary retention if osmotic therapy has been given.

Imaging

- CT brain & cervical spine (or trauma CT if indicated) within 30 minutes of presentation.
- All patients must be transferred to CT by an appropriately trained intensivist or anaesthetist with standard AAGBI monitoring as a minimum (ECG, pulse oximetry, non-invasive blood pressure and end tidal carbon dioxide).
- The CT scan must be reported immediately for life threatening features and by a consultant radiologist within one hour. The scans themselves will need to be transferred electronically to the major trauma centre.
- If a time critical neuro-surgical lesion is identified, then the patient requires rapid transfer by the local team to the regional neurosurgical centre. Refer to the flowchart for the referral pathway and contact details for neurosurgery depending upon which hospital you are in.
- The lack of a working CT scanner constitutes a neurosurgical emergency and should mandate immediate transfer by the referring hospital team. Refer to the flowchart for the referral pathway and contact details for neurosurgery depending upon which hospital you are in.

Neuroprotective measures

- Ensure blood sugar is at least 3mmol/l.
- Ensure the patient's head is in the mid-line position to optimise venous drainage.
- Ensure the bed is tilted to 30 degrees head up.
- Ensure adequate analgesia and sedation (often require large amounts of morphine & midazolam). Muscle relaxation must be maintained during transport.
- Maintain good oxygenation (saturations ≥95% or arterial PaO2 >13kPa).
- Maintain PaCO2 at 4.5-5.3 kPa (this can be correlated with a blood gas which can be venous, capillary or arterial).
- Maintain mean arterial blood pressure according to the targets as above.

- Maintain normothermia - core temperature 36 to 37 °C.
- Load with phenytoin 20mg/kg over 20 minutes as per the BNF for children guidance.
- Intravenous maintenance fluids should be given at 2/3 maintenance. If the patient weighs more than 10kg, use 0.9% sodium chloride as maintenance fluid. If the patient weighs less than 10kg, use 0.9% sodium chloride with 5% dextrose.
- Aim to keep serum sodium between 140 – 150 mmol/l and avoid hyponatraemia. Boluses of 3ml/kg of 3% hypertonic sodium chloride are safe and effective in the management of raised intracranial pressure (see below).

Management of Raised Intracranial Pressure

The clinical signs of raised intracranial pressure include:

- reduced conscious level
- bradycardia
- hypertension
- poorly reactive or fixed dilated pupil(s) (in absence of medical causes)

Hypertension, bradycardia and altered respiration are part of the pathophysiological Cushing's response, typically indicating that a patient is at risk of coning.

Treatment

- Ensure all neuro-protective steps are optimized.
- Place the patient on a manual bagging circuit and initiate manual hyperventilation with 100% oxygen. Reduce the end tidal carbon dioxide level to correlate with a PaCO2 of 4 to 4.5kPa.
- Give hyperosmolar therapy.
    - Either 3% hypertonic sodium chloride 3ml/kg over 15 minutes
    - Or Mannitol 0.5g/kg (2.5ml/kg of 20% solution preferred) over 20 minutes
    - ** Hyperosmolar therapy is an emergency treatment for rapid deterioration and lifesaving intervention prior to definitive treatment by neurosurgery. When administering this treatment, it is also expected that emergency neurosurgery advice is being sought and emergency transfer to neurosurgery is being arranged. **
- Follow hyperosmolar therapy with volume as required to maintain blood pressure. Repeat hyperosmolar therapy as needed.
- Update the regional neurosurgical centre but be mindful that time is of the essence and every effort must be made not to introduce unnecessary delays. Refer to the flowchart for the referral pathway and contact details for neurosurgery depending upon which hospital you are in.

11. Spinal cord injury

A Spinal Cord Injury (SCI) is an insult to the spinal cord at any level resulting in a change, either temporary or permanent in the normal motor, sensory or autonomic function of the cord. Injuries which result from physical trauma are referred to as traumatic and injuries which result from disease or infection are referred to as non-traumatic

Immediate management of traumatic SCI (actual or suspected):

This guideline applies to those that are under the age of 16 years at first presentation, or those already under the care of a paediatric consultant in one of the region's hospitals. If 16 years or over, please refer to the Northern General Hospital, or Pinderfields Pathway for people with SCI.

All patients with a suspected spinal cord injury should be referred to the linked specialist SCI centre with a phone referral to the on-call SCI consultant at the Princess Royal SCI centre(at the Northern General Hospital, Sheffield), or the Yorkshire Regional Spinal Injuries Centre at Pinderfields General Hospital. This should be followed up with an entry to the national SCI database. Spinal Cord Injury (nscisb.nhs.uk)

Think traumatic spinal injury

Following an injury the potential for a spinal cord injury to exist must be considered. Children may present with full movement and sensation of all four limbs; however, they may have a vertebral fracture and, if handled incorrectly, the spinal cord may be damaged and the results could be devastating. Overview | Spinal injury: assessment and initial management | Guidance | NICE

In general, spinal injuries should be suspected in all casualties who have been involved in:

- A road traffic accident
- A fall or jump from a height
- An accident resulting in impact or crush injuries
- An accident resulting in multiple trauma
- An accident resulting in the patient losing consciousness

Spinal Shock

In the acute stage following injury there may be total flaccid paralysis of all skeletal muscle and loss of all spinal reflexes below the level of the lesion. This is referred to as spinal shock and is a neurological phenomenon. It may last from several hours to several weeks depending on the severity.

Early management post injury:

Initial assessment is the standard c-ABC approach as per APLS / ATLS guidelines:

- **C**ontrol massive haemorrhage
- **A**irway with cervical spine control
- **B**reathing with ventilation support
- **C**irculation with haemorrhage control
- **D**isability – AVPU, posture and pupils
- **E**xposure with temperature control

c-ABC is the priority, with protection of any potential unstable fracture. The secondary survey is of greater importance in a patient with impaired sensation.

Airway with Cervical Spine Control

In any injury the airway can become compromised. The spine should be kept in alignment **at all times**.

- Place the patient in a neutral spine position
- Look for evidence of airway obstruction or compromise (eg. Stridor or stertor)
- Use a jaw thrust NOT head tilt/chin lift
- Minimise any movement of the cervical spine

- Consider use of an airway adjunct (NOT nasopharyngeal airway in head injured patients)
- Seek early help from the most experienced anaesthetist available
- Refer to the section on emergency anaesthesia here
- Use appropriate intubation techniques with immobilisation of the spine. In cervical or high thoracic injuries, during intubation severe bradycardia can occur, leading to cardiac arrest. Consider pre-oxygenation, hyperventilation with ambubag (beware risk of aspiration), use of topical anaesthetic spray. Administration of Atropine may be required.

Breathing with ventilation support

The risk of breathing deterioration is high, especially in higher injuries. In cervical and high thoracic injuries, the nerves to the intercostals are paralysed, reducing the ability to breathe effectively. In high cervical lesions the diaphragm may also be affected (C3/4/5). In these high lesions the most affected function is coughing. Patients with very high lesions are breathing with the diaphragm only and have no effective cough at all. The risk of deteriorating respiratory function is extremely high.

Reassess respiratory status regularly:

- Look at the rate and depth of respirations
- Look for shallow or abdominal breathing, asymmetry, or paradoxical breathing
- Slowing respirations, grunting, desaturations are worrying signs
- Look for evidence of aspiration or consolidation
- Have a low threshold for intubation and ventilation prior to transfer to the MTC

Circulation with haemorrhage control (and attention to specific phenomena in spinal injury)

Neurogenic shock is a haemodynamic phenomenon and different to spinal shock. It is the body's response to the sudden loss of sympathetic control below the level of the injury. It occurs in cervical and high thoracic lesions (above T6). Incomplete injuries may not display these signs. Due to lack of vasomotor control significant hypotension results. Bradycardia occurs because of unopposed effects of the vagus nerve. A lower mean blood pressure may be compatible with good urinary output and cannot be used as sole indicator of perfusion. Monitoring of fluid balance in patients with spinal cord injury is essential. Hypovolaemic shock may also be present and other injuries may escape detection in the cord injured patient with sensory deprivation.

There is a high incidence of cardiac contusion in patients with thoracic injuries with a potential for arrhythmia

- Keep patient supine and monitor for bradycardia and hypotension.
- Abnormal vaso-vagal response can occur through stimulation such as suctioning, passing a gastric tube or rapid changes in body position such as log rolling quickly.
- Maintain a normal blood pressure and an adequate urine output for age and size(2mls/kg/hr age < 1yr, 1ml/kg/hr for age 1-12 years old, and 0.5mls/kg/hr for age >12 years).
- Administer IV bolus fluids as needed plus maintenance but be careful not to give too much fluid which may precipitate cardiac failure and pulmonary oedema.
- Vasopressors may be needed to maintain BP, and CVP monitoring may be helpful.
- Problematic bradycardia usually resolves over a few days. Pacemakers can cause management complications in the long term and should be avoided where possible.

Neurological Assessment (all cases)

Careful neurological assessment is **absolutely essential** for patients with spinal cord pathology.

This is very difficult to perform in young children under the age of 5 and in any child when frightened and distressed.

In the first hours and days following injury the neurological level may change. An extension of the lesion by one or even two levels may be observed and it is critical that any change is monitored, to prevent any avoidable deterioration of neurological deficit. Although the gold standard expects neurological observations should be performed at two hourly intervals this is not feasible in young children. Concentrating on a few key points may give better results in combination with attempting to establish level with MRI scan.

At the site of cord injury there will be a zone of critical ischaemia. This zone may expand with poor oxygen saturation or poor perfusion. Patients with high lesions have poor autonomic vascular control and postural hypotension may be severe and significant. In the acute phase of the injury such postural hypotension may expand the zone of critical ischaemia.

Neurological examination should be undertaken by an experienced member of the medical team as soon as possible following spinal cord injury. The Gold standard assessment for documentation of spinal cord injury is the ISNCSCI (International Standards of Neurological Classification of SCI) produced by the American Spinal Cord Injury Association (ASIA Chart, see appendix). Mark the sensory level on the patient as this is very useful in subsequent review. A change from an accurately recorded level may allow diagnosis of potential complications, e.g., epidural haematoma, over distraction when using skull traction. In the period of spinal shock formal classification of the injury is not possible.

There are no national guidelines on how often the ISCNSCI should be completed in paediatric patients but as a minimum it should be done as soon as possible after admission, and at 1 week and 1 month after admission - although more frequently if signs are changing. Spinal nursing observations should be carried out more frequently, although in children it can be hard to achieve the 2 hourly gold standard. The medical team should advise on the minimum frequency of spinal observations.

Sacral segments have great prognostic significance for recovery as well as bowel and bladder management. Careful examination of perianal sensation, deep anal pressure, tone, and voluntary anal contraction is important but not usually possible in younger children and has to be considered for each child as the information may be extremely unreliable. If being assessed it should be assessed by the most senior clinician available and only when indicated for formal neurological assessment. If not performed the reason for this should be documented for each individual.

Spinal surgery may be contemplated. If spinal surgery is undertaken the ISNCSCI score must be carefully completed both prior to surgery and post-operatively. Remember this is, however, less reliable in the presence of spinal shock.

Steroid Therapy Post Injury

There is no evidence that high dose steroids have any place in the management of acute traumatic spinal injured children.

Transfer to the Regional Spinal Centre

Decisions regarding transfer should be made by senior staff in both the transferring and receiving paediatric units. The Major Trauma Networks have agreed an **immediate acceptance policy.**

The referring team may require advice regarding stabilisation and transfer, and this can be facilitated via Embrace via the call conference system. When transport is provided by the referring hospital teams the principles of safe transfer should be followed – please refer here to Section 19.

Special Considerations in Transferring a patient with SCI:

- The clinical team transferring the patient should have the skills and equipment to manage deterioration on route and consideration should be given to the level of spinal injury when assessing this risk.
- A properly immobilised spinal cord injured patient can be transferred at normal road speed and sudden acceleration/deceleration should be avoided.
- Particular attention should be given to skincare and pressure areas

Handling the Child and Young Person with a traumatic SCI

Patients are usually transferred into Emergency Departments on a scoop stretcher. Transfer onto an appropriate support surface MUST be undertaken at the earliest possible opportunity. In the Emergency Department this will be onto a sheet over a vacuum mattress on a standard padded tipping trolley. Ensure sufficient personnel are available for continued maintenance of spinal alignment. Ensure all head huggers and straps are removed before transfer.
No log roll is required to be removed from a scoop stretcher as the two sides can be split and removed laterally.
When moving a child, avoid shearing their skin against the underlying surface.

To ensure that total protection and alignment of the spine is maintained, to allow the patient to be moved, the recommended technique which can be applied is the logroll. It is vital that staff are trained in the technique of log rolling and that the person at the head end takes the lead.

RCEM has issued a position statement referencing both APLS and NICE guidance:

- In conscious children, use manual in-line stabilization (MILS) whenever possible
- In unconscious children, or when MILS cannot be maintained, immobilization should be with a properly fitting collar, blocks, and tape.
- If no properly fitting collar is available, then blocks or rolled blankets should be used to provide an immobilisation device.

Patients with acute spinal cord injury must be nursed flat initially. Elevation of the whole body up to 15 degrees may assist ventilation. Pressure reducing dynamic air mattresses are contraindicated in unstable injuries and turning regime should be initiated to prevent pressure ulceration.

Skull traction in children must be reviewed on an individual case basis as in young children the majority of injuries are unstable in traction. Children cannot be transferred in traction.

Patients with acute spinal cord injury must be nursed flat initially. Elevation of the whole body up to 15 degrees may assist ventilation. Pressure reducing dynamic air mattresses are contraindicated in unstable injuries and turning regime should be initiated to prevent pressure ulceration. The

proportionally larger size of the head in young children must be accounted for and when the child is lying supine the body may have to be supported higher to prevent ongoing flexion deformity of the neck .

The lead consultant and/or spinal injury consultant must document the plan for each individual child in terms of their early mobilisation in their medical notes. This plan must be followed by all members of the MDT.

Imaging

Most paediatric major trauma patients do not require spinal imaging of any form. In cases where risk of or clinical suspicion for vertebral fracture exists, regional Trauma Network guidance should be followed on which patients require spinal imaging. This guidance follows the National Major Trauma Imaging Protocols for paediatric patients produced by the Royal College of Radiologists. Plain view radiological assessment is still first line choice for the majority of these patients.

In clinically suspicious/confirmed SCI imaging the whole spine is essential - usually with MRI of the whole spine. Areas of concern may then require localised CT. Young children may present without obvious bony injury of vertebrae; SCIWORA (SCI without radiological abnormality, though significant damage may be seen on MRI). A high index of suspicion is needed re disco-ligamentous injuries. A senior paediatric radiologist should interpret these scans.

Spinal Surgery

Spinal surgery comprises two components; decompression of the neural tissues and reduction and stabilisation of the spine. Conservative management is also appropriate in some injuries.

The role of decompression in the management of patients with spinal cord injury has yet to be fully determined. The only definite indication for decompression and stabilization is progressive neurological deterioration. Benefits and risks of surgery should be evaluated and discussed.

12. Peripheral vascular injuries including use of tourniquets

Background

Within UK trauma systems, most vascular injury will be the result of blunt rather than penetrating mechanisms. However, delayed diagnosis of vascular compromise is more common following blunt injury. Amputation rates are lower after penetrating than blunt arterial injury. Rapid assessment and treatment is required to maximize limb salvage.

Network referrals

Time critical transfers to the Leeds Major Trauma Centre should follow the standard pathway here Stabilize, arrange immediate transfer and inform ED consultant at LGI.

When time permits contact the on call vascular surgeon via LGI switch board to warn them the patient is coming and provide ATMIST hand over (see under telephone advice below for contact details).

ALL ISCHAEMIC LIMBS SHOULD BE CONSIDERED TIME CRITICAL

Telephone advice

It is expected that non time critical emergency transfers will be unusual with most cases justifying use of the time critical pathway here. Telephone advice is available by contacting the appropriate vascular surgeon directly:

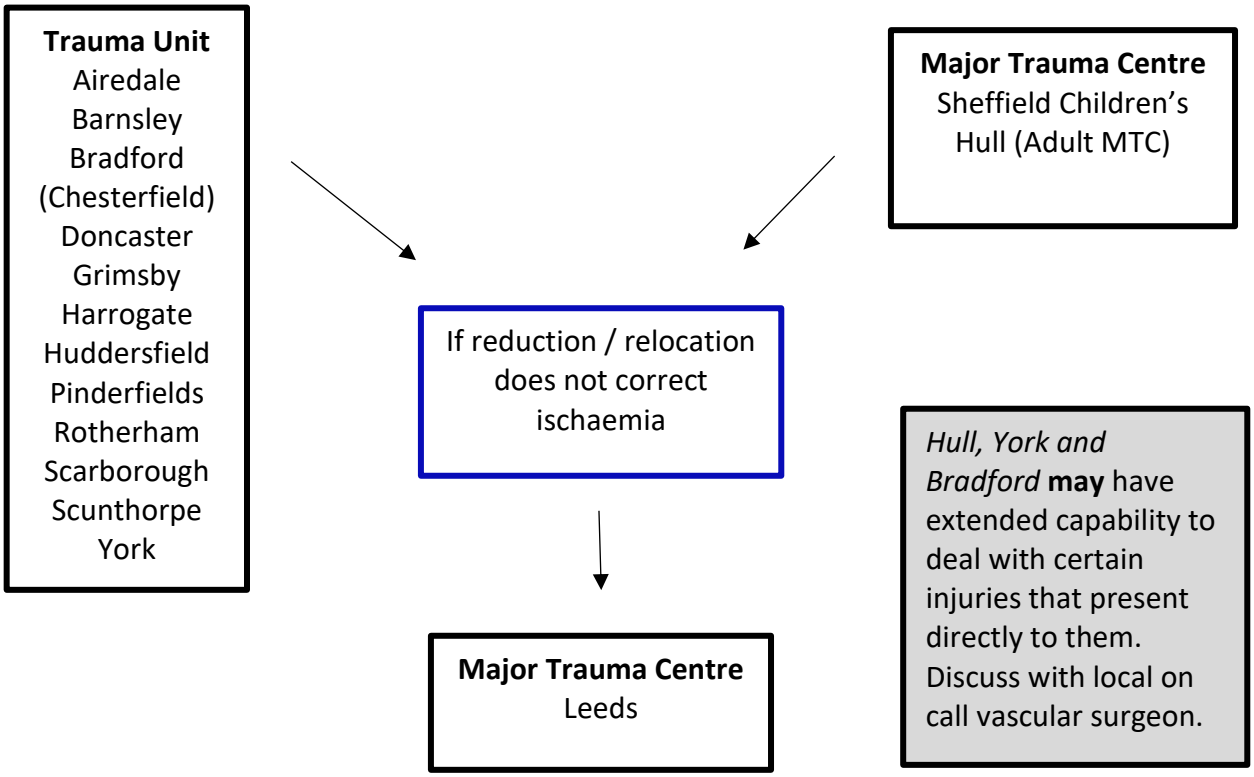
Week days: Between 08.00 - 18.00 the case should be discussed with the on-call Consultant Vascular Trauma Surgeon (switch board 0113 243 2799).

Week days: From 18.00 - 08.00 the case should be discussed with the on-call resident Vascular Registrar or Vascular Consultant (switch board 0113 243 2799).

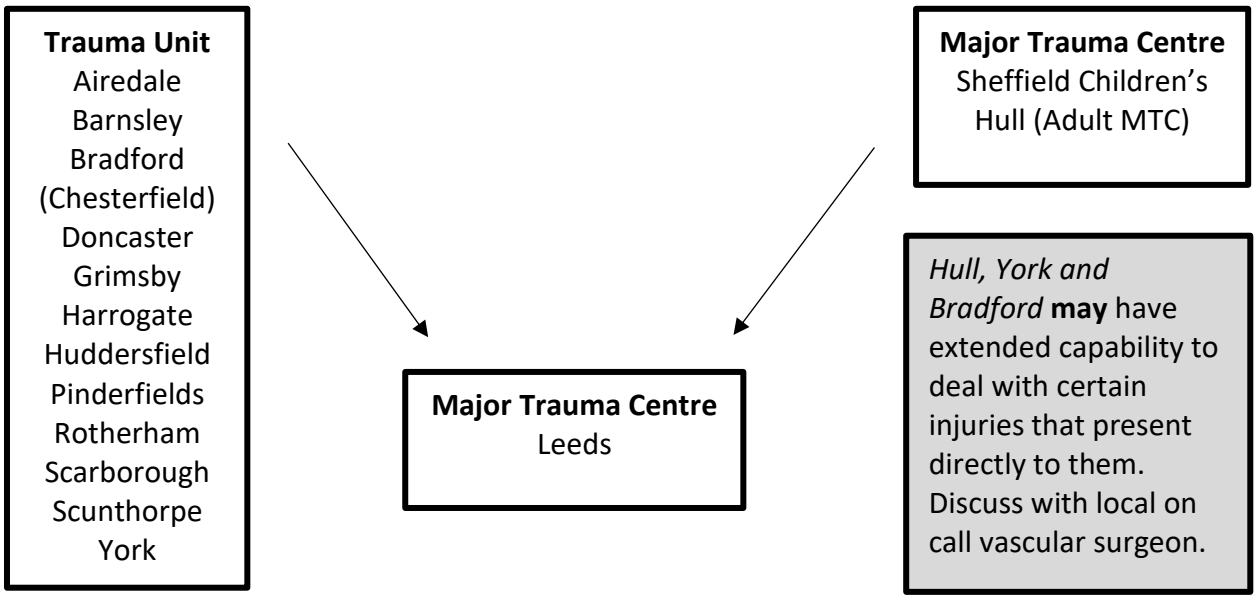
Weekends: The case should be discussed with the on-call resident Vascular Registrar or first on Vascular Consultant (switch board 0113 243 2799).

Patient Flows

(a) After diagnosis of ischaemic limb secondary to blunt trauma



(b) After diagnosis of ischaemic limb secondary to penetrating trauma



General principles of care

Initial assessment & management

The hospital teams should receive an ATMIST handover from the prehospital team. The patient should be assessed by the trauma team as per APLS / ATLS guidelines.

In the absence of associated blunt trauma a cervical collar is not indicated for a patient with penetrating injury and if fitted may obscure wounds. Only when there are neurological signs attributable to penetrating injury to the neck is C-spine protection indicated.

Patients with penetrating injury must be log rolled to identify all sites of injury. Beware of missing wounds within skin creases especially axilla and perineum.

Active bleeding from wounds should be controlled with direct pressure (bandage or fingers). Rarely and only when this fails and it is felt that the limb may need to be sacrificed to save life should a tourniquet be applied to a limb on the direction of the team leader. It should be applied as distally as possible.

Vascular and neurological examination of the limb should be undertaken. If there is concern regarding a vascular injury, pressure measurements can be taken: an ankle brachial pressure index (ABPI, lower limb only) or an arterial pressure index (API, upper or lower limbs). An API is defined as the Doppler systolic arterial pressure distal to the site of injury divided by the Doppler systolic arterial pressure measured at the same point in the uninjured extremity. An ABPI or API >0.9 indicates a very low risk of a significant arterial injury.

<u>If you feel the patient requires time critical transfer do not image as this delays transfer. Imaging is only appropriate if you plan to manage the patient locally.</u> Plain radiographs (with markers on skin wound) of the injured part should be undertaken for gunshot injury. Trajectory determination is

helpful to injury identification and to detect bone fractures. Radiographs for stab wounds may reveal retained foreign material. Paper clips taped to skin make useful skin markers with intact clips used for anterior wounds and o*p*ened clips for *p*osterior wounds.

Management

Patients with limb ischaemia secondary to displaced, angulated long bone fractures and / or joint dislocations e.g. knee or ankle dislocation, mid shaft femoral or supracondylar humeral fracture, should have the injury realigned or relocated as quickly as possible. This will require appropriate analgesia with neurological and vascular examination documented both before and after any manipulation.

In general, patients with hard signs of vascular injury (List 1) require urgent operative intervention. Those with exsanguinating active bleeding and / or rapidly expanding haematoma require immediate operative intervention for haemorrhage control.

List 1: Hard signs of vascular injury

External pulsatile bleeding

Large, expanding, pulsatile haematoma

Palpable thrill or audible bruit

Absent distal pulse

Signs of distal ischaemia (pain, pallor, paralysis, paraesthesia, perishingly cold)

Even in the presence of hard signs, preoperative imaging may help guide surgical decision making and may be performed if the patient's haemodynamic condition allows. Such situations include:

- When difficult to determine precise site of injury e.g. skeletal injury especially the mangled limb, long wound tracts parallel to course of vessel or multiple pellets from shot gun wounds.
- Patients with preexisting arterial disease / abnormalities.
- Clinical concern that hard signs may be due to extensive bone & soft tissue injury without actual vascular injury.

Metallic foreign bodies (retained knife blade, pellets & bullets) will produce artefact on CT angiography but usually result in images of sufficient quality for decision making. Digital subtraction intra-arterial angiography or on table angiography may be required in selected cases. If preoperative imaging is indicated it must be undertaken rapidly to reduce ischaemic time to a minimum.

List 2: Soft signs of vascular injury

History of arterial bleeding at the scene (no ongoing bleeding)

Small, non expanding, non pulsatile haematoma

Shock with no other injury (suggesting large volume blood loss)

Weak pulse

Injury to anatomically related nerve

Proximity of wound to vessel

Ankle brachial pressure index <0.9 or arterial pressure index <0.9 or dampened flow on Doppler examination

Patients with soft signs of vascular injury (List 2) require further assessment with a low threshold for imaging. Those with penetrating injury have 3-25% chance of significant injury. A CT angiogram is likely to be first line investigation but artefact from retained foreign bodies may occasionally necessitate intra-arterial angiography.

Patients with a normal vascular and neurological examination with an ABPI or API >0.9 are extremely unlikely to have a significant arterial injury and do not usually require further vascular investigation. In particular, patients following knee dislocation with normal ankle pulses and ABPI or API >0.9 do not usually need further imaging. However, the requirement for imaging following knee dislocation is debated and the case for imaging should be considered on a case by case basis.

See Appendix 6 – management of significant bleeding from a limb and use of tourniquets

13. (a) Management of open fractures

WOUND management

1. Photograph of the wound
2. Remove gross contamination (i.e. leaves, etc.)
3. Cover the wound with saline soaked gauze dressings but do not explore or irrigate.
4. Leave wound and dressing undisturbed thereafter.
5. Check Tetanus status
6. Give ASAP Antibiotics IV according to local guidelines. Leeds as follows:
    a. **Co-Amoxiclav** 30mg/kg IV (max 1.2g) tds
    b. **True penicillin allergy: Clindamycin** 6.25 mg/kg IV (max 600mg) qds and **Gentamicin** 2.5mg/kg
7. Continue Antibiotics IV for 72hrs or until definitive skin closure
8. At Induction: single doses of **Gentamicin** 2.5mg/kg and **Teicoplanin** 10mg/kg IV (max 400mg) for initial debridement and every secondary procedure until definitive skin closure

FRACTURE management

1. Neurovascular Examination & Documentation
2. Align and Splint the fracture
3. Repeat Neurovascular Examination
4. XRAYs – CT imaging as required
5. Document all findings

DEFINITIVE management

1. Decision balanced between oncall MTC Consultant, Plastic Surgery and Vascular Surgery consultants. Complex injuries, particularly those potentially requiring local or free tissue transfer, or with neurovascular injury should be immediately transferred (A&E to A&E) to the paediatric MTC offering these resources.
2. Timing depends on other injuries and available expertise.
3. Bone and soft tissue debridement, Wound coverage and fixation should be within 24hrs
4. Severely contaminated injuries, farmyard / aquatic involvement, compartment syndrome, remain a surgical Emergency and MUST be Debrided in Theatres **ASAP**
5. **Definitive soft tissue Coverage – Fixation** optimally within 72hrs

BRITISH ORTHOPAEDIC ASSOCIATION & BRITISH ASSOCIATION OF PLASTIC, RECONSTRUCTIVE & AESTHETIC SURGEONS AUDIT STANDARDS for TRAUMA

DEC 2017

Open Fractures

Background and justification

Open fractures may require timely multidisciplinary management. The consequences of infection, can be great both for the individual patient and the community. Trauma networks and hospitals require the appropriate pathways and infrastructure, to manage these patients, to enable optimum recovery and to minimise the risk of infection.

Inclusions:

All patients with open fractures of long bones, hind foot or midfoot (excluding hand, wrist, forefoot or digit).

Standards for Practice

1. Patients with open fractures of long bones, hind foot or midfoot should be taken directly or transferred to a specialist centre that canprovide Orthoplastic* care. Patients with hand, wrist, forefoot or digit injuries may be managed locally following similar principles.
2. Intravenous prophylactic antibiotics should be administered as soon as possible, ideally within 1 hour of injury.
3. There should be a readily accessible published network guideline for the use of antibiotics in open fractures.
4. The examination of the injured limb should include assessment and documentation of the vascular and neurological status. This shouldbe repeated systematically, particularly after reduction manoeuvres or the application of splints. Management of suspectedcompartment syndrome should follow BOAST guidelines.
5. The limb should be re-aligned and splinted.
6. Patients presenting with arterial injuries in association with their fracture should be treated in accordance with the BOAST for arterial injuries.
7. In patients where an initial "Trauma CT" is indicated there should be protocols to maximise the useful information and minimise delay:
   - The initial sequence should include a head to toes scanogram. This should be used with clinical correlationto direct further specific limb sequences during that initial CT examination.
   - There should be a local policy on the inclusion of angiography in any extremity CT related to open fractures.
8. Prior to formal debridement the wound should be handled only to remove gross contamination and to allow photography, thendressed with a saline-soaked gauze and covered with an occlusive film. 'Mini-washouts' outside the operating theatre environmentare not indicated.
9. All trauma networks must have information governance policies in place that enable staff to take, use and store photographs of openfracture wounds for clinical decision-making 24 hours a day.
10. Photographs of open fracture wounds should be taken when they are first exposed for clinical care, before debridement and at otherkey stages of management. These should be kept in the patient's records.
11. The formation of the management plan for fixation and coverage of open fractures and surgery for initial debridement should be undertaken concurrently by consultants in orthopaedic and plastic surgery (a combined orthoplastic approach).
12. Debridement should be performed using fasciotomy lines for wound extension where possible (see overleaf for recommendedincisions for fasciotomies of the leg)
    - Immediately for highly contaminated wounds (agricultural, aquatic, sewage) or when there is an associatedvascular compromise (compartment syndrome or arterial disruption producing ischaemia).
    - within 12 hours of injury for other solitary high energy open fractures
    - within 24 hours of injury for all other low energy open fractures.
13. Once debridement is complete any further procedures carried out at that same sitting should be regarded as clean surgery; i.e. thereshould be fresh instruments and a re-prep and drape of the limb before proceeding.
14. Definitive soft tissue closure or coverage should be achieved within 72 hours of injury if it cannot be performed at the time ofdebridement
15. Definitive internal stabilisation should only be carried out when it can be immediately followed with definitive soft tissue cover.
16. When a decision whether to perform limb salvage or delayed primary amputation is indicated, this should be based on amultidisciplinary assessment involving an orthopaedic surgeon, a plastic surgeon, a rehabilitation specialist, the patient and theirfamily or carers.
17. When indicated, a delayed primary amputation should be performed within 72 hours of injury.
18. Each trauma network should submit appropriate data to the TARN, monitor its performance against national standards and audit its outcomes.
19. All patients should receive information regarding expected functional recovery and rehabilitation, including advice about return to normal activities such as work and driving.

*The BAPRAS/BOA group recommend that for clarity the narrative description of an Orthoplastic Service by NICE is broken into its component parts as follows: a combined service of Orthopaedic and Plastic Surgery Consultants; sufficient combined operating lists with consultants from both specialties to meet the standards for timely management of open fractures; scheduled, combined review clinics for severe open fractures; specialist nursing teams able to care for both fractures and flaps. In addition, an effective orthoplastic service will also: submit data on each patient to the national trauma database (TARN) and hold regular clinical audit meetings with both orthopaedic and plastic surgeons present. Please note: the definition of an Orthoplastic Centre was updated in November 2019.

13. (b) Management of extremity compartment syndrome

Compartment syndrome is a severe time-dependent condition characterised by challenges to its diagnostics, straight forward therapeutic management, and detrimental irreversible consequences if it is neglected.

It arises from an increase in intra-fascial pressure in the compartments. It can affect all regions of the extremities, primarily the tibial region. Causes include direct trauma, burns and compression as a result of prolonged positioning (eg. lying on leg in an unconscious state).

Recommended standards (adaptation of BOAST 10)

- Assessment for compartment syndrome must be part of the routine evaluation of patients who present with significant limb injuries, OR after surgery for limb injuries, AND after any prolonged surgical procedure which may result in hypo perfusion of a limb.
- Clear documentation should include:
    - Time and Mechanism of injury
    - Time of evaluation
    - Level of Pain
    - Level of Consciousness
    - Response to Analgesia
    - Whether a Regional Anaesthetic is given.
- The key clinical findings are
    - Pain out of proportion to the associated injury
    - Pain on passive movement of the muscles of the involved compartments
    - Tense compartments painful to press
    - Limb neurology and perfusion, including capillary refill and distal pulses, should be clearly documented but do not contribute to early diagnosis of the condition.
- Patients documented to be AT RISK for compartment syndrome should have routine nursing limb observations for these early signs and these should be recorded.
- These observations should be performed hourly whilst the patient is deemed still to be at risk. If pain scores are not reducing, then SENIOR CLINICAL REVIEW i.e. ONCALL MTC / ORTHOPAEDIC CONSULTANT or ONCALL SENIOR REGISTRAR is mandated.
- In high-risk patients, regional anaesthesia should be avoided as it can mask the symptoms of compartment syndrome. In addition patient-controlled analgesia with intravenous opiates can also mask the symptoms. When evaluating these patients, the rate and dose of opiates and other analgesics must be taken into consideration and recorded in the medical records.
- Patients with symptoms or clinical signs of compartment syndrome should have all circumferential dressings released to skin and the limb elevated to heart level. Measures should be taken to maintain a normal blood pressure.
- Patients should be re-evaluated within 30 minutes. If symptoms persist then urgent surgical decompression should be performed. Alternatively, in situations where the clinician is not completely convinced by the clinical signs, compartment pressure measurements should be undertaken. All actions should be recorded in the medical records.
- Compartment syndrome is a surgical emergency and surgery should occur within an hour of the decision to operate. If the patient is in a Trauma Unit and the local expertise allows and

when other life-threatening injuries are not present, then the decompressive surgery should be undertaken in the trauma unit rather than enforcing a delay with a transfer to the MTC.

- FOR PATIENTS WITH DIAGNOSTIC UNCERTAINTY and those with risk factors where clinical assessment is not possible (e.g. patients with reduced level of consciousness):
    - Intra-fascial pressures should be measured objectively and documented without delay
    - Compartment pressures exceeding 40 mmHg, OR, in the case of hypotension, exceeding a difference between the DBP (diastolic) and the intra-fascial chamber pressure of <30 mmHg are classed as critical values and are an indication for fasciotomies in the unconscious patient
    - It must be noted that the accuracy of the compartment pressure measurement depends on the examiner and can be false-positive/negative.
    - Following measurement - should either proceed to surgical decompression or continue to be monitored. This decision should be made be an orthopaedic / plastic surgical or vascular consultant.

Surgery

- Immediate open fascial decompression of all involved compartments, taking into account possible reconstructive options.
- Necrotic muscle should be excised. The compartments decompressed must be documented in the operation record.
- In the presence of a fracture skeletal stability should be provided, such as with monolateral external fixation.
- All patients should undergo re-exploration at approximately 48 hours, or earlier if clinically indicated. Early involvement by a plastic surgeon may be required to achieve appropriate soft tissue coverage.
- For lower leg fasciotomies it is recommended to perform a two-incision four-compartment decompression (BOAST 4).
- Patients with late presentation or diagnosis (greater than 12 hours) have a high risk of complications with surgery. Decision-making is difficult and should involve two consultants. Non-operative management is an option.
- In case of vascular reconstruction the indication for fasciotomies should be considered and applied early; if necessary it should be carried out even before the vascular reconstruction.
- Postoperatively the patient should be covered with antibiotics as per the paediatric open fracture guidelines.

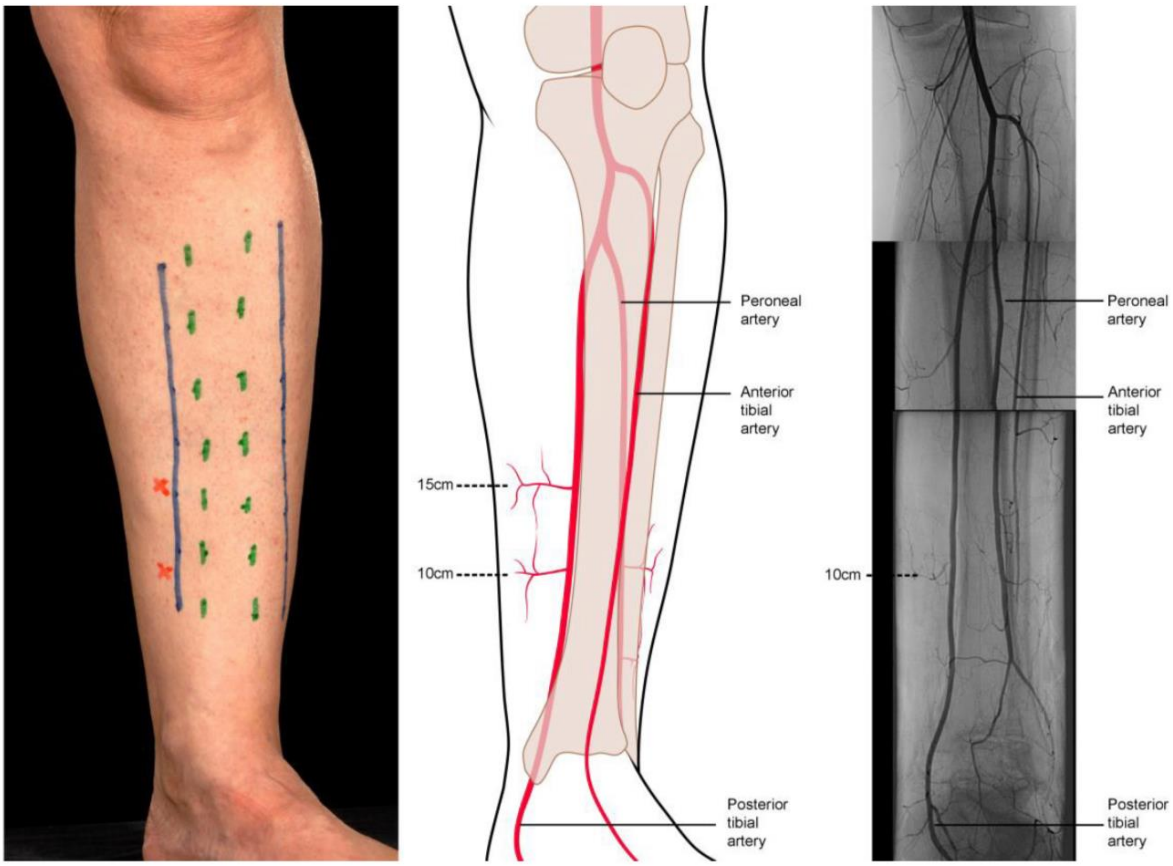


Figure showing recommended incisions for wound debridement and fasciotomies in the leg. The medial incision alone is usually sufficient for debridement and preserves the perforators arising from the posterior tibial vessels, which form the basis of local fasciocutanoeus flaps. It also provides access to the posterior tibial artery and venae commitans when required as recipient vessels for free flaps. The lateral incision is used for decompression of the anterior and peroneal compartments in patients with compartment syndrome. (A) Margins of subcutaneous border of the tibia marked in green, access incisions marked in blue and perforators arising from the medial side as red crosses. (B) Line drawing depicting the location of the perforators, with approximate indicative distances from the tip of the medial malleolus. (C) Montage of arteriogram.

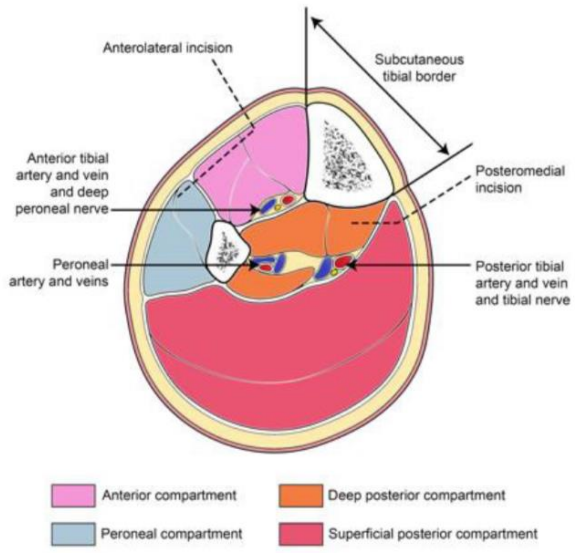
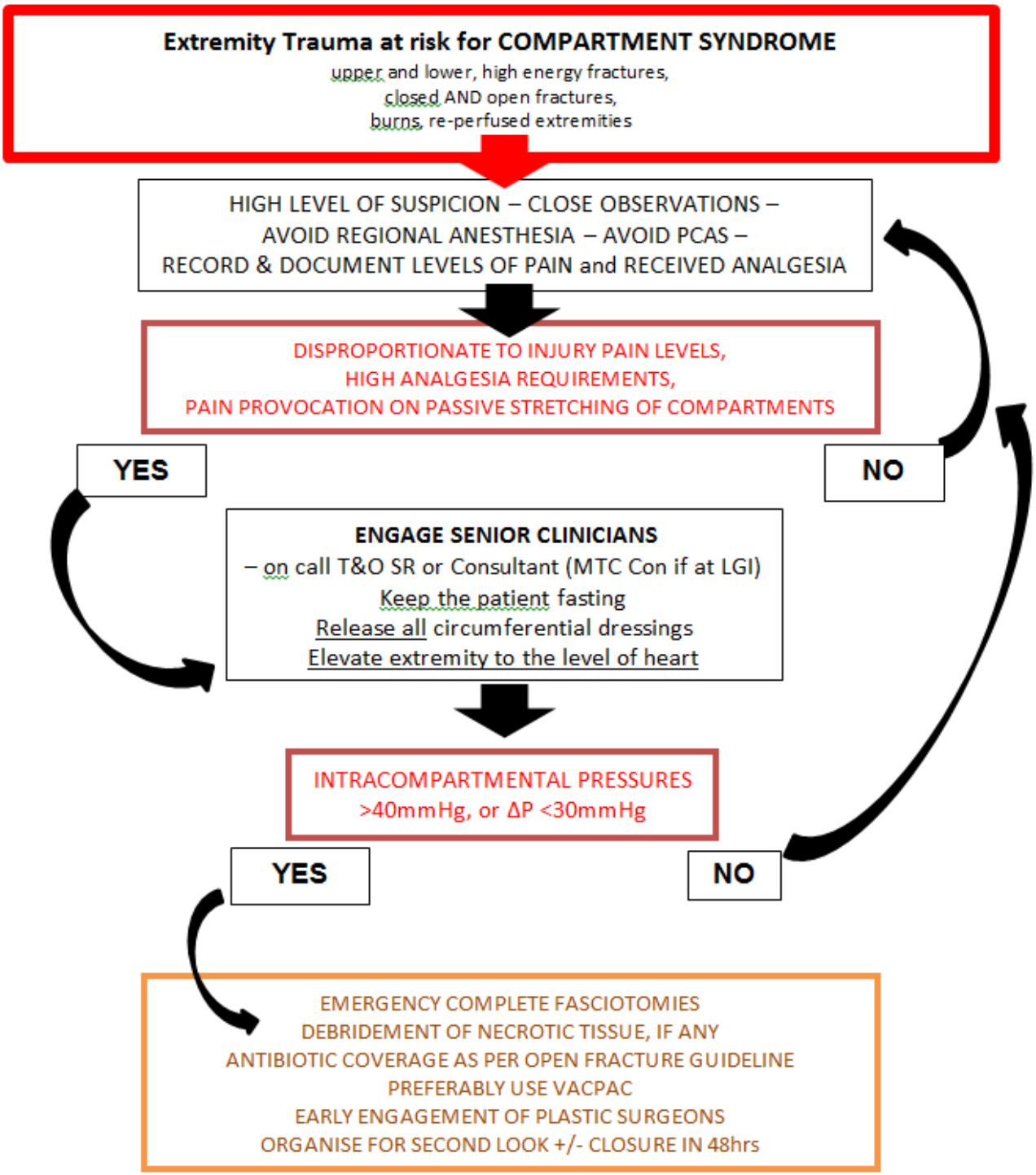
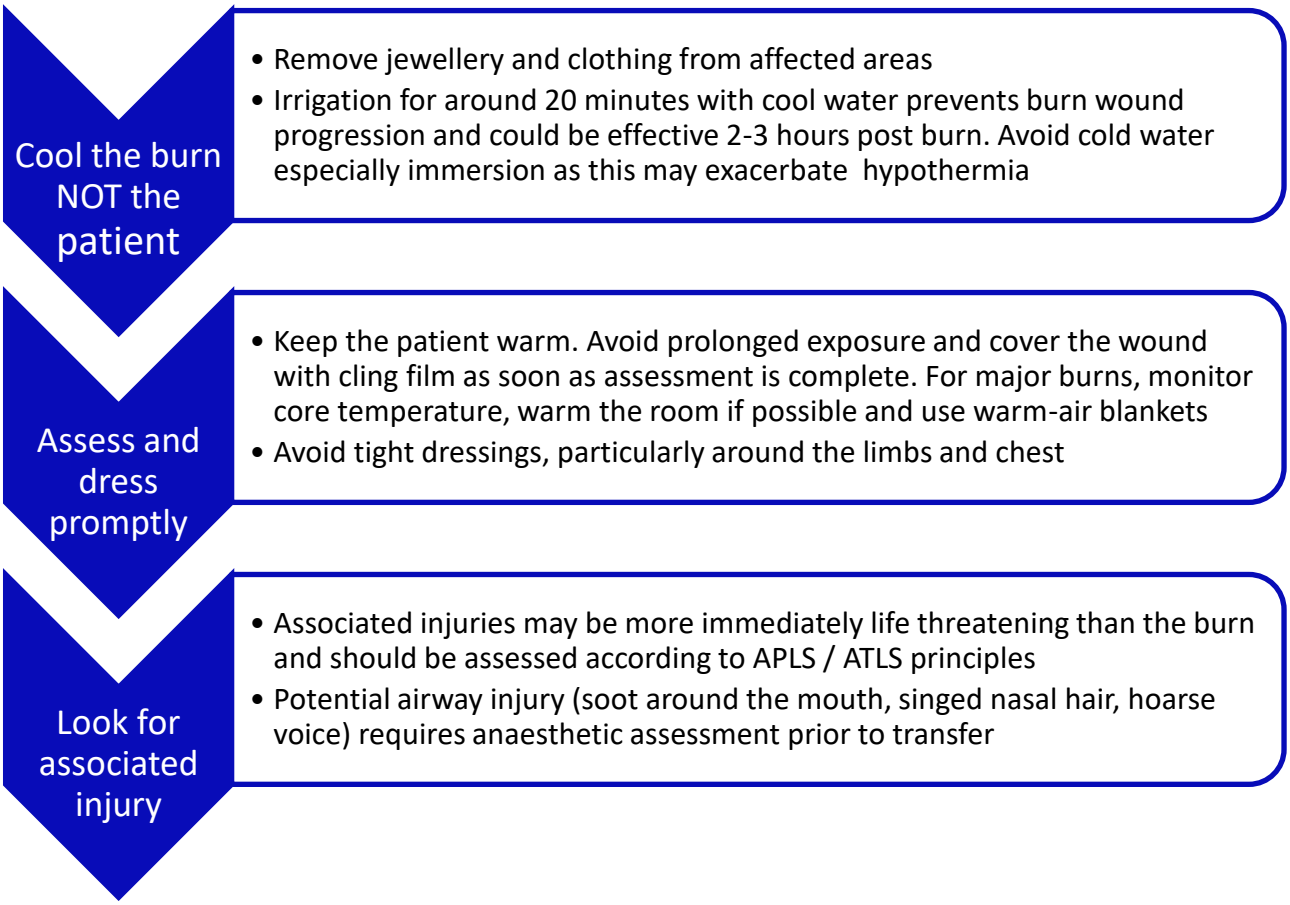


Figure showing cross section through leg showing incisions to decompress all four compartments


Extremity Trauma at risk for COMPARTMENT SYNDROME
upper and lower, high energy fractures,
closed AND open fractures,
burns, re-perfused extremities
HIGH LEVEL OF SUSPICION – CLOSE OBSERVATIONS –
AVOID REGIONAL ANESTHESIA – AVOID PCAS –
RECORD & DOCUMENT LEVELS OF PAIN and RECEIVED ANALGESIA
DISPROPORTIONATE TO INJURY PAIN LEVELS,
HIGH ANALGESIA REQUIREMENTS,
PAIN PROVOCATION ON PASSIVE STRETCHING OF COMPARTMENTS
YES
NO
ENGAGE SENIOR CLINICIANS
– on call T&O SR or Consultant (MTC Con if at LGI)
Keep the patient fasting
Release all circumferential dressings
Elevate extremity to the level of heart
INTRACOMPARTMENTAL PRESSURES
>40mmHg, or ΔP <30mmHg
YES
NO
EMERGENCY COMPLETE FASCIOTOMIES
DEBRIDEMENT OF NECROTIC TISSUE, IF ANY
ANTIBIOTIC COVERAGE AS PER OPEN FRACTURE GUIDELINE
PREFERABLY USE VACPAC
EARLY ENGAGEMENT OF PLASTIC SURGEONS
ORGANISE FOR SECOND LOOK +/- CLOSURE IN 48hrs

14. Burns – initial management and referral criteria

First aid



Management

Calculate and document Total Burn Surface Area (TBSA) and depth using a paediatric Lund and Browder Chart – Appendix 7

Less than 10% TBSA	No fluid resuscitation if oral intake is adequate
10% or more TBSA	Calculate resuscitation fluid requirements using the modified Parkland formula

Parkland formula

Fluid volume (ml) = weight (kg) x TBSA x 3

Divide total calculated fluid volume by two and then:

- Complete the first half by 8 hours **from the time of the burn**
- Give the second half over the next 16 hours

Give Hartmann's solution (preferred) or 0.9% Sodium Chloride for resuscitation.
Additional maintenance fluids should be given +/- Potassium Chloride.

Other priorities

- Application of a dressing helps with pain but additional analgesia is usually required
- Does the patient require tetanus prophylaxis?
- Avoid prophylactic antibiotics unless otherwise indicated

Don't forget analgesia

Referral criteria

Children with a burn **and** other life-threatening injuries should be transferred to the nearest Children's MTC.

Refer to a Burns Unit if:

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

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

In the Leeds Children's MTC region burns care is co-ordinated from the Burns Unit at Pinderfields 01924 541931. Complete MDSAS Referral online referral with photo and discuss with Pinderfields Burns Unit via Plastics Surgical Registrar.

In the Sheffield Children's MTC region burns care is co-ordinated from the Burns Unit at Sheffield Children's Hospital (SCH) 0114 2260694. Complete MDSAS Referral online referral with photo and discuss with SCH burns unit via Plastics Surgical Registrar.

For more information on the Yorkshire & Humber Burns Pathway including which children should be referred to Manchester Burns Centre see Guidelines - Sheffield Children's NHS Foundation Trust (sheffieldchildrens.nhs.uk) Burns and Trauma section.

Patients requiring HDU or PICU level care should be referred via Embrace on 0114 305 8200 sheffieldchildrens.nhs.uk/embrace

15. Facial and dental injuries

Priorities in management

Best practice is based on current APLS / ATLS guidelines.

Maxillofacial injuries will often take a lower priority than other potentially life or limb threatening injuries. This is due to the ability to deal with most maxillofacial injuries in a timescale from 24 hours to 7 days without long-term morbidity.

There are a few exceptions to this rule and they are highlighted in the guidelines below.

For splinting of the face in facial trauma with uncontrollable bleeding see Appendix 8.

PURPLE	Time critical lifesaving intervention needed (or multi system injuries individually needing specialist care) ED to ED transfer, no speciality permission required
RED	Time sensitive intervention required. May be able to stay locally if max fax on site. If being transferred in the context of multi system trauma should only go to paediatric MTC (Leeds / Sheffield)
AMBER	Delayed treatment required. May be able to stay locally if max fax on site If being transferred in the context of multi system trauma should only go to paediatric MTC (Leeds / Sheffield) If isolated injury may be able to go to another Trauma Unit with max fax on site
GREEN	Non-emergency /elective. May be able to stay locally if max fax on site If being transferred in the context of multi system trauma should only go to paediatric MTC (Leeds/Sheffield) If isolated injury may be able to go to another Trauma Unit with max fax on site

Location of services and referral pathways for Yorkshire & Humber

In the child with multiple trauma they will be transferred to the Major Trauma Centre (MTC) according to the usual major trauma pathway (see Section 3). Each MTC will have maxillofacial support available to them.

Some Trauma Units will be able to provide paediatric management in the following circumstances:

- Absence of other injuries which would require immediate transfer to the Paediatric MTC
- Age > 2 years

MTC	Centres with maxillofacial resident on call		
Leeds General Infirmary 0113 243 2799 Bleep 1782	Leeds General Infirmary 0113 243 2799 Bleep 1782	Bradford Royal Infirmary 01274542200 Bleep 284	Pinderfields General 01924 541000 01924 546333 (direct)
Sheffield Children's Hospital 0114 271 1900 07623869543 Bleep 2027	Royal Hallamshire 0114 271 1900 07623869543 Bleep 2027	Barnsley 01226 730 000 Bleep 173	Chesterfield 8am to 5pm 01246 277 271 Bleep 861 **Out of hours refer to Sheffield Children's Hospital**
Hull Royal Infirmary 01482 328 541 Bleep 128	Hull Royal Infirmary 01482 328 541 Bleep 128	York District Hospital 01904631313 Bleep 861 (Harrogate refer to York)	

PENETRATING NECK INJURY		
Presentation	**Consideration**	**Management**
Stable patient No airway compromise Haemodynamically stable No haematoma No bruit No mediastinal widening No voice changes No cranial nerve injury	Contact vascular surgery and maxillofacial surgery (NB vascular surgery only available in Leeds) CT angiogram and interventional radiography management of bleeding sites Tetanus and antibiotics	Surgery if patient deteriorates or other injury identified on CT scan Otherwise observe and monitor closely
Unstable patient Airway compromise Haemodynamically unstable Neck haematoma Uncontrollable bleeding Mediastinal widening Voice changes Cranial nerve injury	Immediate surgical intervention after control of the airway Tetanus and antibiotics	Multi-specialty surgical input – paediatric surgery, vascular and/ or maxillofacial surgery

Tissue injuries

The management of soft tissue injuries often involves debridement and closure by the maxillofacial team within 24 to 48 hours unless there is a need to control bleeding.

SOFT TISSUE INJURY – SPECIAL CONSIDERATIONS ACCORDING TO SITE			
Site	**Pitfall**	**Immediate Management**	**Definitive management**
All sites	Dirty wound	Irrigation, tetanus, antibiotics and dressings	Debridement, washout and closure
All sites	Consider chemical injury	Remove any causative foreign body	Irrigate immediately with 0.9% sodium chloride
Scalp	Haematoma formation	Control bleeding and pressure dressing	Debridement and washout Monitor haemoglobin
Ears	Haematoma	Drainage to avoid cartilage collapse	Compression bandage
Nose	Septal haematoma and tissue loss	Drain haematoma with needle puncture	Tissue loss requires secondary reconstruction
Lips	Vermillion border scars	Irrigation, identify foreign body	Debridement and closure of wound
Intra-oral lacerations	Infection	Lacerations < 1.5cm require oral hygiene measures only	Large wounds require debridement and closure within 72 hours
Pre-auricular	Facial nerve and parotid injury	Document facial nerve function. Identify salivary leak	Exploration of wounds, repair and closure

Eyelid	Lacrimal flow damage/underlying damage to the globe	Full eye assessment is required	Repair of eyelid with duct cannulation (Ophthalmology +/- Maxillofacial)

HARD TISSUE INJURY			
Site	**Presentation**	**Immediate Management**	**Definitive Treatment**
Skull	Skull laceration, low GCS, CSF leak, "Panda eyes," Battles sign, haemotympanum	Refer to section on Severe traumatic brain injury **insert hyperlink** Follow local guidelines for vaccination with CSF leak	Neurosurgical management
Orbit - white eye blowout or entrapment (of muscle or fat)	Diplopia, bruising around eye, numbness of cheek, vagal symptoms (bradycardia, syncope, nausea, vomiting, hypotension when asked to move affected eye) - <u>can be mistaken for intracranial injury</u>	Rule out globe injury CT orbits with coronal formats (fine cut) Consider steroids	Contact oral and maxillofacial surgeon If no other injuries then EUA and release of entrapment in theatre within 24 hours to reduce risk of persistent diplopia
Orbit - compartment syndrome or retrobulbar haemorrhage	Pain, proptosis, reduced acuity, paraesthesia of cheek, hard / tense globe	Lateral canthotomy +/- cantholysis Mannitol, acetazolamide, steroids	If no other injuries then EUA and control of bleeding in theatres
Nose	Difficult to assess if swollen Deviation of nose, septal haematoma, epistaxis	Drain septal haematoma, control epistaxis- may need ENT input	MUA nasal bones when swelling reduces in 48-72 hours
Orbital floor injury (no entrapment of muscles or fat)	Bruising of eye with double vision and often identified on CT scan Enophthalmos	Visual acuity and assess for globe injury	ORIF of fracture site within 5-7 days
Zygoma/ midface	Flattening of cheekbone complex, double vision, enophthalmos, inability to open mouth, malocclusion due to mobility of maxilla, bruising of palate, epistaxis, numbness of cheek	Assess for globe injury and record visual acuity Treat emergency as per orbital injury Ask patient not to blow nose. No routine antibiotics	ORIF fractured bones in 5-7 days Complex maxillary fractures require management within 24 hours
Mandible including	Bleeding from mouth, inability to bite, malocclusion, numbness	Treat as open fracture and administer antibiotics (except condyles)	ORIF of fracture within 24 hours (can delay treatment if other life

condyles & ramus	of lower lip on one or both sides	Ensure airway secure in **bilateral** fractures	threatening injuries present). Condylar fractures rarely require ORIF under age 12

BITE INJURY		
Type	**Consideration**	**Management**
Human	Usually dirty High risk for contamination and transmissible disease	Swab wounds, Tetanus / immunization history, consider transmissible diseases, photograph, irrigate Antibiotics - co-amoxiclav remains first line Consider non-accidental injury and if suspected refer to paediatrician
Animal	May be clean or dirty Lower risk for contamination than human bite	Swab wounds, Tetanus / immunization history, photograph, irrigate Antibiotics (Commonest organism from dog bite - Pasteurella species) - co-amoxiclav remains first line Consider non-accidental injury and if suspected refer to paediatrician

Dental and dentoalveolar trauma – see also tooth avulsion treatment algorithm Appendix 9

Dental trauma should be triaged and managed based on damage to deciduous teeth (baby teeth) or adult teeth which begin to erupt from the age of 6 sequentially replacing baby teeth with their adult counterparts.

Scenario	Action	Consideration
Acute trauma patient with loose teeth / debris considered to be airway risk	Remove any loose teeth or fractured crowns deemed to compromise airway	Unaccountable teeth- consider CXR to rule out inhalation
Avulsed or subluxed/displaced teeth	Follow algorithm – Appendix 9	Contact maxillofacial bleep holder/ SpR on call

- **Avulsed deciduous (baby) teeth** do not require re-implanting in the acute setting.

- **Avulsed adult teeth** should be re-implanted as quickly as possible (as long as this does not compromise the management of other issues such as the airway management or management of other injuries). This can be performed (ideally within 1 hour of avulsion) by handling the tooth by the crown and sliding the root back into the socket.

- **Dentoalveolar fractures** involve the tooth bearing bone in the mandible and maxilla. Fractured segments will have multiple teeth that move in unison when palpated. These fractures are rare, and should raise suspicion of a fracture of the major bones in the face if mobility is seen.

Following initial management, children should be referred to their dental practitioner or a specialist paediatric dentist at the earliest opportunity for definitive management.

16. Eye injuries

Location of services and referral pathways for Yorkshire & Humber

In the child with multiple trauma they will be transferred to the Major Trauma Centre (MTC) according to the usual major trauma pathway (see Section 3). Each MTC will have ophthalmology support available to them.

History Mechanism, previous eye pathology

Look Subconjunctival haemorrhage, lid lacerations, foreign bodies, fluorescein staining of cornea / conjunctivae

Check Visual acuity, pupils (anisocoria, unreactive to light / peaked, red reflex, eye movement, proptosis

Immediate referral to ophthalmology if any concerns about

- globe integrity
- intraocular foreign bodies
- chemical / thermal injuries
- retrobulbar haemorrhage
- orbital cellulitis / collection
- significantly reduced vision

Immediate management

Open globe injury	Instil one drop preservative free chloramphenicol drop and cover with plastic eye shield (not eye pad) to protect against external pressure
Chemical / thermal injury	Remove any causative foreign body Irrigate eyes immediately with at least one litre 0.9% sodium chloride Check pH using indicator paper. Irrigate until neutral.
Retrobulbar haemorrhage	Refer to max fax or attempt lateral canthotomy and cantholysis with local anaesthetic
Orbital cellulitis / collection	Consider CT orbits, sinuses and brain ENT review
Significantly reduced vision - unknown cause	Urgent referral to ophthalmology registrar on call
Suspected abusive head trauma	Should have dilated eye examination and retinal photos within 24 hours of referral
Orbital floor fractures with inferior rectus entrapment	Can have minimal swelling but can get bradycardia, especially in up gaze Order CT orbits and ask max fax to operate urgently**.**

Who to call

Leeds Teaching Hospital (in hours or out of hours):

- On call registrar on mobile via LTHT switchboard 0113 243 2799
- Consultant on call on mobile via LTHT switchboard 0113 243 2799

Sheffield Children's Hospital:

- In-hours- ophthalmology nurse triage service- 0114 243 4343 bleep 250
- Out-of-hours- on call ophthalmology registrar via Hallamshire switchboard 0114 271 1900

17. Imaging and interventional radiology

Background and risks from ionising radiation

These guidelines have been adapted from the Leeds Major Trauma Centre Imaging in Paediatric Major Trauma guidelines Written by Dr Annmarie Jeanes (Consultant Paediatric Radiologist).

They should be read in conjunction with the following documents:

BFCR(14)8 Royal College of Radiologists Paediatric Trauma Protocols, Aug 2014
Paediatric trauma protocols | The Royal College of Radiologists (rcr.ac.uk)

NICE NG232 Head Injury: assessment and early management, May 2023 *Overview | Head injury: assessment and early management | Guidance | NICE*

NG40 *NICE's guideline on major trauma service delivery* for recommendations on prehospital triage, transfer and pre-alert procedures, procedures for receiving people in trauma units and major trauma centres, documentation, monitoring and audit, and access to major trauma services

The 'routine' recommendation of head - symphysis CT scanning in adult patients cannot be directly transferred to children. The spectrum of trauma, surgical management and outcome is different from adults, and thus 'head to toe' whole body CT is often not necessary, or indeed appropriate.

Despite the benefits of CT, the disadvantage is the exposure to ionising radiation.

Children (particularly girls) are at greater risk than adults of detrimental effects from ionising radiation. This has been demonstrated in epidemiologic studies of exposed populations.

The reasons for this are twofold:

1. Their longer life expectancy results in a larger window of opportunity for the effects of radiation damage to be expressed.

2. Children's organs are more radiation sensitive. Although the energy imparted from the radiation exposure is less than in adults, the corresponding organs are also smaller, resulting in a marked increase in organ dose - and therefore patient-effective dose. A 1 year old infant is 10–15 times more likely to develop cancer than an adult for the same exposure and radiation dose.

The ALARA Principle

As medical practitioners it is our responsibility to ensure that exposure to medical ionising radiation for all patients should always be kept to a minimum and the ALARA principle (an acronym formed from the phrase "As Low as Reasonably Achievable") should be followed.

- Any imaging involving ionising radiation must be justifiable
- For an individual child, the benefits of a properly performed and clinically justified CT should always outweigh the risks
- The exposures should be adjusted accordingly to ensure a diagnostic study at the lowest dose ie specific Paediatric weight based protocols should be used.
- Multiple phase CT scans should only be used when clinically appropriate.

Choice of imaging modality

The most appropriate imaging modality will be covered in more detail by anatomical area in the subsequent sections. However, the following general statements regarding each modality can be made.

Ultrasound

In the acute paediatric trauma setting there is no role for ultrasound outside of assisting in interventional procedures.

MR

In the acutely injured child, magnetic resonance (MR) imaging is primary reserved for potential spinal cord injury, though it is acknowledged that access to MR imaging may be difficult.

Plain radiography

The value of a normal radiograph for specific areas (chest and c-spine) should not be underestimated.

The chest radiograph is the primary investigation for blunt chest trauma and should be performed as part of the primary survey in children who have been the victim of major trauma.

If there is clinical suspicion of an isolated c-spine injury, clinical examination and plain c-spine radiographs are normally sufficient to exclude bony injury.

A primary survey pelvic radiograph is not indicated in the paediatric population.

CT

As discussed whole body CT is often not necessary, or indeed appropriate. However, targeted use of CT forms the major component of major trauma imaging in children. The indications for CT will covered by anatomical area in the subsequent sections.

Although whole body CT should not be considered a routine investigation in injured children, it can be used in selected cases where patients have clearly suffered severe injury to more than one body region and the overall risks and benefits have been carefully considered.

If CT is deemed the most appropriate investigation, appropriate dose reduction procedures must be in place. This includes dose reduction software, iterative reconstruction software and use of judicious kilovolt and milliampere reduction. Radiosensitive areas such as the lens, thyroid and breast should be avoided where possible.

Chest trauma

The chest radiograph is the primary investigation for blunt chest trauma and should be performed as part of the primary survey in children who have been the victim of major trauma.

Further imaging (with contrast-enhanced chest CT) should be dictated by the nature of the trauma, the clinical condition of the child and the initial radiographic findings.

Isolated chest CT can be performed in the arterial phase, however when the chest is imaged together with the abdomen and pelvis, a single-volume dual-contrast acquisition (e.g. Camp Bastion contrast) is advised to minimise radiation burden.

Chest CT is not required if the chest radiograph is normal, the patient is conscious and clinically stable as it is unlikely to lead to a change in management.

Penetrating trauma is an indication for contrast-enhanced chest CT due to the incidence of occult vascular injury.

Head trauma

The RCR guidance on imaging in paediatric trauma states:

"CT is the primary investigation for cranial imaging in the child who has suffered head trauma. It displays high sensitivity and specificity for identification of traumatic brain injury and is readily available in most centres. However the dose of ionising radiation required for cranial CT has been demonstrated to be associated with an increased incidence of cancer and it should not be used for all children with head injury. The indications for cranial imaging have therefore been evaluated by the National Institute for Health and Care Excellence (NICE) and are summarised in the algorithm presented." (Figure 2).

"All children with head injuries should be assessed by an appropriately trained professional within 15 minutes of hospital presentation, and immediately if there is any reduction in conscious level. Adequate resuscitation, clinical examination and administration of analgesia should take place in the process of deciding whether to perform CT."

"Isolated head injuries are common in childhood and fulfilling the criteria for a cranial CT scan is not an indication on its own for a CT of the cervical spine or any other body part."

"Cranial CT should be performed before administration of intravenous contrast. Following the ALARA principle, avoidance of the lens should be optimised."

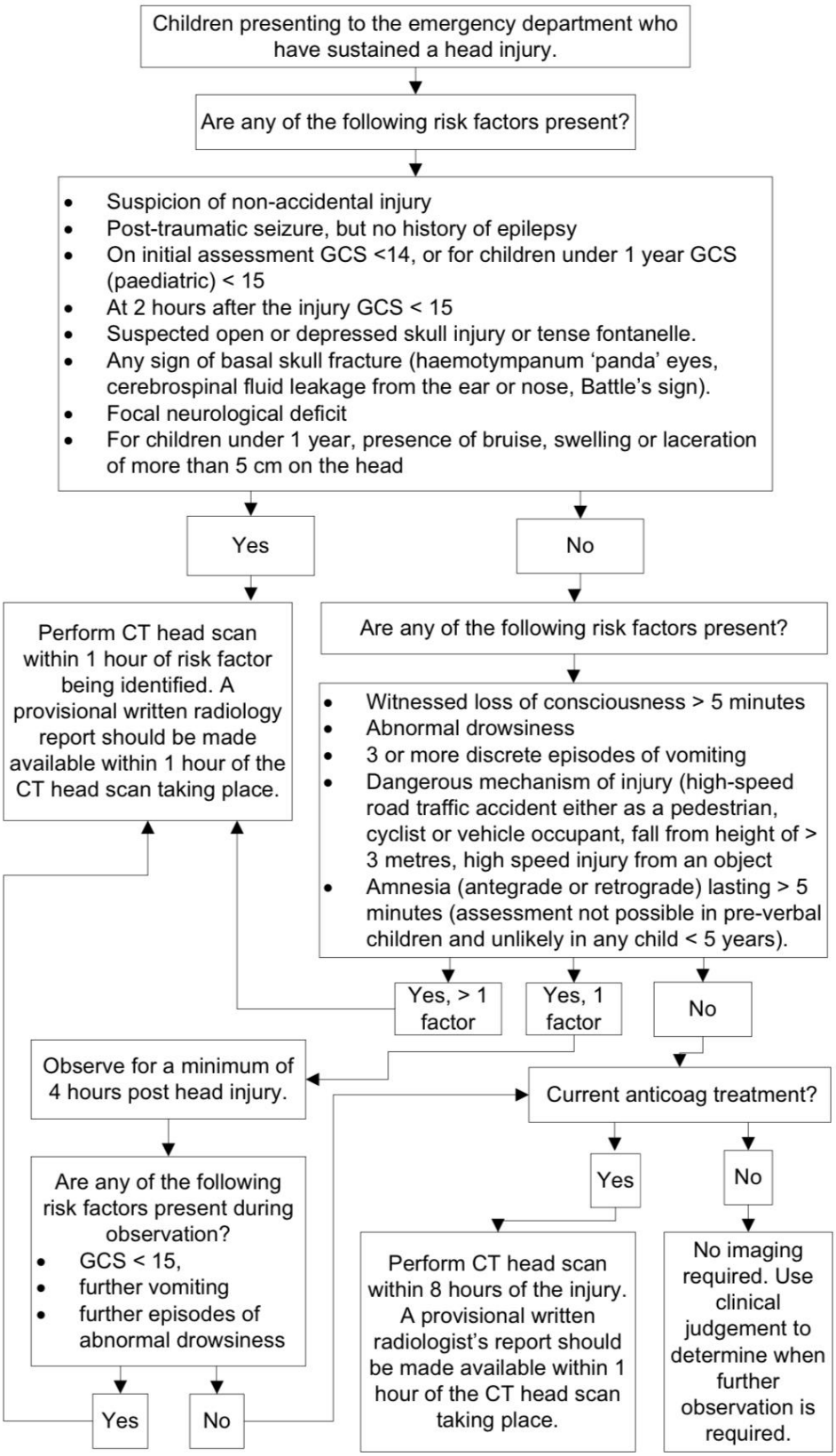


Figure 2. Selection of children for a CT head scan National Institute for Health and Care Excellence. *CG 176 Head Injury: Assessment and early management.* Jan 2014 (updated Sep 2019)

Cervical spine trauma

Paediatric cervical spine injury is uncommon.

Appropriate clinical evaluation must be undertaken before imaging is performed as it is an anatomical area that is relatively radiosensitive. Prior to cervical spine imaging a full history and examination must be performed where possible, with any imaging being complementary to other features elicited. Imaging should not be used in isolation as a diagnostic measure.

When spinal injuries do occur in children they are more likely to involve the cervical spine. This is due to both physiological and anatomical differences between young children and adults. These include a relatively high fulcrum, larger head, horizontal facets, flatter vertebral bodies, and ligamentous laxity.

Initial imaging of the cervical spine may be with plain radiographs or CT scan depending on the clinical situation.

The radiation burden associated with imaging of the cervical spine in children is significant. There is a linear relationship between radiation exposure to the neck in children and the development of thyroid cancer, with the strongest association being in children < 15 years at the time of exposure. CT is superior in the diagnosis of fractures; however the dose to the thyroid is reported to be 90- 200 times higher with CT, the greatest risk being in children less than 5 years old.

Given the propensity of ligamentous injury and radiation risks in children, the cervical spine should, where possible, be 'cleared' using a combination of conventional radiography and clinical examination. Plain radiographs still have a substantial role in alert, symptomatic patients. Adequate radiographs of the cervical spine may exclude significant bony injury and obviate the need for CT. Where plain radiographs are indicated, an adequate cervical spine series must include:

(i) Lateral cervical spine X-ray to include the base of skull and the junction of C7 and T1
(ii) Antero-posterior cervical spine x-ray to include C2 to T10 and
(iii) An adequate peg view if attainable.

Peg views may be difficult in young children. However it is recommended that if they can obey commands and open their mouth a peg view should be attempted.

In a stable child undergoing cranial CT, discussion between senior radiologists and senior clinicians as to the most appropriate imaging of the neck (where clinically indicated) is advised. It is inappropriate to perform cervical spine imaging automatically when performing cranial imaging without appropriate discussion.

It must also be remembered that due to ligamentous laxity in children, both plain radiography and CT may be normal despite significant ligamentous and spinal cord injury. In children less 5 years old, given the radiation burden from CT and insensitivity of CT to ligamentous injury, MRI rather than CT

should be considered. MRI should also be considered as the primary imaging modality where there are definitive neurological signs.

Figure 3 shows the process for selection of children for imaging of the cervical spine employed in the NICE guideline (CG176) which refers primarily to management of head injury. Please note that presence of head injury alone is not sufficient to enter the starting point of the algorithm; rather there must be clinical suspicion (based on history or examination) of potential cervical spine injury.

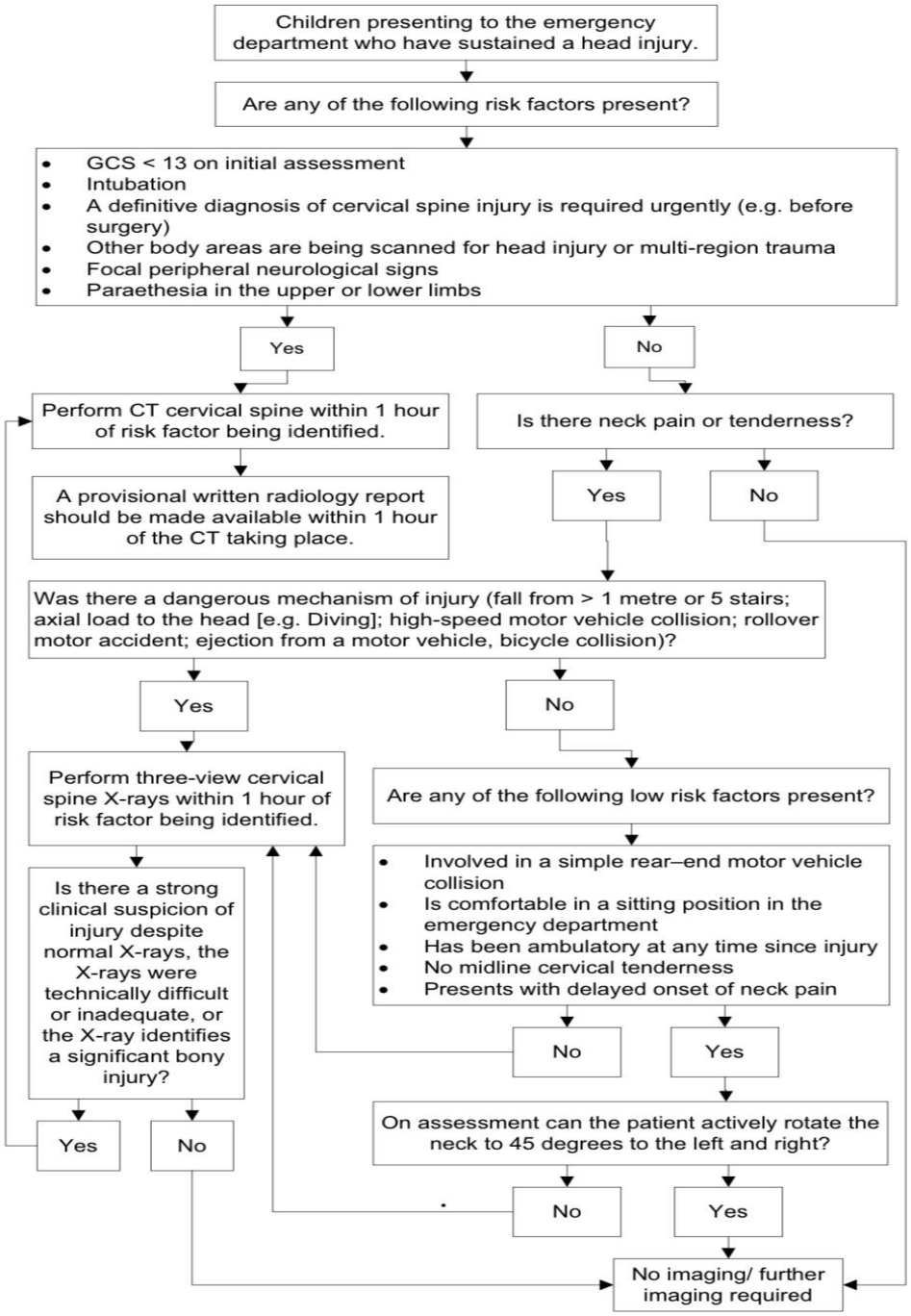


Figure 3. Selection of children for imaging of the cervical spine. National Institute for Health and Care Excellence. *CG 176 Head Injury: Assessment and early management.* Jan 2014 (updated Jun **2017)**

Abdominal and pelvic trauma

The majority of abdominal trauma in children and adolescents occurs secondary to a blunt impact, with RTCs, pedestrian vs. vehicle collisions and falls being the most frequently reported causes. Other common mechanisms of injury include recreational accidents, particularly bicycle handlebar injuries, off road quad biking and contact sports. These seemingly trivial mechanisms may however result in severe injuries. Abdominal trauma is rare in infants and young children, with head injury being much more frequent. The most common cause of abdominal trauma in this age group is inflicted trauma.

Contrast-enhanced CT is the modality of choice for the assessment of acute traumatic intra-abdominal injury. There are no mechanisms of injury which mandate abdominal CT as an isolated factor. Decision to perform abdominal CT should be made on the basis of the clinical history and examination.

The following clinical variables have been found to be associated with intra-abdominal injury and may indicate the need for abdominal CT:

- Lap belt or handle bar injuries
- Abdominal wall ecchymosis
- Abdominal tenderness in a conscious patient
- Abdominal distension
- Clinical evidence of persistent hypovolaemia; for example, persistent unexplained tachycardia
- Blood from the rectum or nasogastric tube.

When CT is clinically indicated a single-volume dual-contrast acquisition (e.g. Camp Bastion contrast, figure 4, overleaf) is advised to minimise radiation burden. As the abdomen and pelvis form one anatomical compartment, the scan field should extend to the symphysis pubis inferiorly. If there is a high likelihood of active arterial bleeding multi-phase imaging (arterial and portal venous +/- delayed) may be required. Delayed phase imaging / CT cystography may be required if the initial imaging suggests suspected renal / bladder trauma respectively. Multi-phase imaging and CT cystography would normally be performed in the tertiary referral centre where ultimate management will take place.

Pelvic fractures are rare in children and therefore a primary survey pelvic radiograph is not indicated in the paediatric population. In the context of major trauma the bony pelvis will be included on CT.

Interventional radiology

Paediatric patients who require interventional radiology should be treated in a dedicated tertiary referral centre by an expert in interventional radiology with appropriate skills where possible. The child with major trauma will be transferred to the Major Trauma Centre (MTC) according to the usual major trauma pathway with direct ED to ED referral (see Section 3). It is imperative that all relevant imaging is transferred to the tertiary referral centre, ideally electronically via PACS.

Preparation for CT and scan technique

- In stable patients, obtain chest radiograph prior to CT.
- Discuss clinical details with radiologist, agree on imaging strategy and place request.
- If required, head and c-spine CT is performed unenhanced (no administration of IV contrast)

- If required, thoracic, abdominal and pelvic CT is IV contrast enhanced. Ensure intravenous access prior to transfer. This should be the largest cannula possible, ideally in the right ACF.
- IV Contrast: single-volume dual-contrast acquisition (e.g. Camp Bastion contrast, Figure 4)
- Clamp the urinary catheter if present.
- If necessary, decompress the stomach with an NG tube.
- Enteric contrast is not required. This includes penetrating trauma.

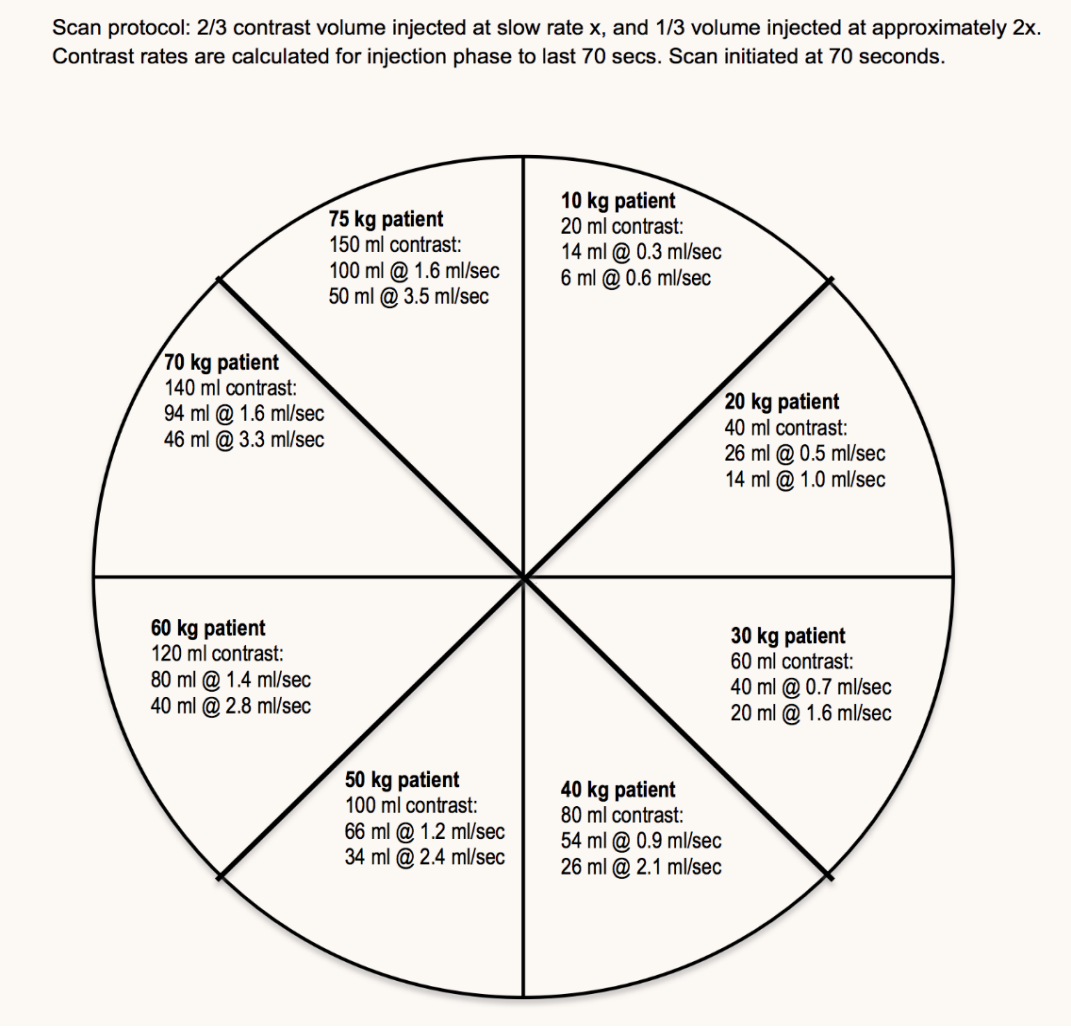


Figure 4. Camp Bastion contrast wheel. Developed by Dr Richard Miles. *BFCR(14)8 Royal College of Radiologists Paediatric Trauma Protocols*. Aug 2014.

Reporting

- An acute primary assessment report (example provided, Appendix 10) should be completed immediately, ideally prior to the patient leaving the CT department.
- A full report should be available within 1 hour. This may be a provisional report, in which case a consultant verified report should be completed within 24 hours.

18. Analgesia, including for chest trauma with rib fractures

This guideline covers the assessment and early management of pain in paediatric major trauma patients in the Emergency Department.

Assessment of pain

Choose a pain assessment tool appropriate for the child's age and developmental stage. The gold standard of assessment is the ability to self report.

Prehospital analgesia

Many children will NOT have been given any pain relief before reaching hospital.
Always confirm if any prehospital analgesia has been administered, such as:

- Oral paracetamol
- Entonox in the awake older child
- Intranasal or intravenous opiates
- Ketamine in the awake child with blunt trauma

Early pain management in the Emergency Department (ED) – also see flow chart Appendix 11

(a) Non-pharmacological measures

Pain management starts with your approach to a distressed and injured child:

- Engage the help of an appropriately trained therapist, play specialist or nurse
- Use the presence of a parent if possible as a source of comfort for the child
- Reducing anxiety helps reduce pain levels and this can be achieved by explaining, talking and to a degree by distraction.

Consider using non-pharmacological means of pain relief early - eg. for burns apply burns shields initially or more definitively use a clear dressing such as cling film.

Don't forget that reduction of displaced fractures and dislocations immediately reduces the severe pain associated with the abnormal anatomy and this can then be maintained with appropriate splintage.

When these measures have been addressed then the next step will be pharmacological agents; all the above can be actioned while drug doses are being calculated and drawn up.

(b) Pharmacological measures

Aggressive use of multimodal therapy in all stages should be used to control pain
Assess patient's pain on presentation to ED using appropriate assessment tool
Reassess pain scores at regular intervals and top up pain relief as needed.

Options

- Intra-nasal diamorphine 100micrograms/kg
- Paracetamol IV or orally
- Morphine IV dose is 50-200microgram/kg (up to a max of 10mg)
- Ketamine IV dose is 250-300 microgram/kg (can be administered via IV, IM, oral or buccal routes)
- Shorter acting opioids e.g. fentanyl and alfentanil for rapid pain control (experienced personnel only who would be competent at managing the airway)
- Peripheral nerve blocks (trained personnel only), using 0.25% levobupivacaine maximum 2mg/kg, = maximum volume of 0.8mL/Kg
    - Femoral nerve block or fascia iliaca block: fractures of the femur
    - Brachial plexus blocks: upper limb injuries
    - Intercostal nerve blocks: rib fractures
- NSAIDs usually have no role in the immediate management of major trauma.

See also Appendix 11: Pain management flow chart

19. Secondary trauma transfers

- The transferring team (TU / LEH) call their local ambulance service and state "*Emergency Interfacility Transfer for Child Major Trauma Victim*"
    - Yorkshire Ambulance Service 0330 330 0276
    - East Midlands Ambulance Service 0115 967 5097
- Almost all major trauma transfer requests will require a CATEGORY 2[1] response.
- If, in the opinion of the senior clinician in charge, the patient requires a category 1 response then they should request that "*the incident is escalated to a team leader or a clinical manager to call back to review with the senior clinician".*

C - Massive haemorrhage

Check tourniquets are tight and keep them visible. Document time applied. Consider placement of pelvic binder. Splint long bones. Give Tranexamic Acid bolus, if appropriate, before departure and consider starting infusion. Follow guidance for transfer and administration of blood products.

A - Airway and C-spine

Use capnography. Check tube position with chest X-ray. If not intubated take RSI drugs pre-drawn up in single dose labelled syringes. Check suction is charged and working. Note tube length at lips before departure. Blocks and tape should be used for C-spine immobilization. Use a vacuum mattress if one is available.

B - Breathing

Always have a self-inflating bag, mask and oropharyngeal airway available. Ensure chest drains are secured to trolley and visible. Place gastric tube and empty stomach prior to travelling to avoid vomiting and aspiration.

C - Circulation
Take a fluid bolus drawn up ready in case. Ideally this should be blood in the child with circulatory compromise, prescribed, checked and attached to the patient via a giving set and three-way tap. Have a spare IV access available. If IO in situ, ensure it is secure and visible throughout.

D - Disability
Check pupils, recheck every 15 mins if head injury and take osmotic diuretic pre-drawn up. Check blood glucose prior to departure. If using muscle relaxant, take additional single doses pre-drawn up.

E - Everything else
Ensure patient is secured safely to trolley, use a vacuum mattress if available or rolled blankets to minimise movement. Check temperature and maintain normothermia with blankets, hat etc.

	Minimum equipment list - pre-prepared grab bag preferable		
	Spare ETT and one size smaller, laryngoscope		Large bore cannula for needle decompression
	Self-inflating bag, mask, oropharyngeal airway		Scalpel for thoracostomy
	Suction with suction catheters and yankauer		Fluid bolus drawn up
	Adequate oxygen supply		Osmotic diuretic dose drawn up in head injury
	RSI drugs drawn up		Enteral syringe to aspirate gastric tube
	Muscle relaxant doses in single aliquots		Pen torch
	Enough sedation for journey + 30 mins at MTC		Stethoscope
			Paperwork

Checklist prior to leaving

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

	Documentation and communication (*as appropriate)
	Update the parents on the child's condition and the plans for transfer
	Photocopies of the notes, investigations results, drug chart*
	Highlight / document any safeguarding concerns*
	Transfer radiology by PACS (CD or hard copy are alternatives)
	Maternal blood sample (6ml EDTA) for babies under 4 months

	Patient preparation (*as appropriate)
	Spinal immobilisation
	ETT secured and position confirmed on CXR (mid-trachea)*
	On transport ventilator with continuous etCO2 monitoring*
	Recent blood gas demonstrates adequate gas exchange and normal blood glucose
	Adequate analgesia, sedation and muscle relaxation*

	Chest drainage of pneumothorax / haemothorax
	Gastric tube on free drainage
	Urinary catheter in situ and draining freely*
	Immobilisation of long bone fractures, pelvic binder in situ
	Minimum 2 points of IV access and well secured
	Maintenance fluids and all other infusions fully labelled
	Pupillary responses monitored and recorded regularly
	Seizures controlled and metabolic causes excluded
	Maintain temperature above 36.5 ^{o}C
	Adequate patient monitoring – ECG, BP, SaO_2, $etCO_2$, Temp
	Patient and equipment adequately secured
	Emergency airway, breathing equipment and adequate gases
	Emergency fluids and drugs

Top Tips

Communication
When phoning MTC check seniority of person on phone, Trauma Team Leader if possible
Be clear and concise, use ATMIST (age, time, mechanism, injury, signs and treatment)
Phone MTC shortly after leaving with accurate ETA from driver
Phone MTC again when 15 minutes away so that trauma call can be put out in good time

Relatives
Consider arranging separate transport for family, to allow you to focus on patient
Police sometimes happy to help out with care and transfer of the parents
Document contact details for relatives before they leave
Do not allow them to chase the ambulance

999 Crew
Ensure one crew member stays in the back with you, and ask them to document observations
Determine driving style before departure i.e. “fast but smooth”, patient stability and safety will be compromised by excessive braking and cornering
Discuss actions in case of emergency with 999 crew - “Stop now” vs “Stop when safe”

Documentation
Bring paperwork from primary transfer, if arrived by ambulance
Copy notes from trauma call in your hospital
Document AMPLE history (Allergies, Medications, PMHx, Last meal, Events)
Put a patient ID band on child prior to departure, preferably with NHS number

Personal preparation
Hand over all clinical responsibilities and bleep
Ensure phone fully charged, with MTC number saved
Have two pens, pen torch, stethoscope, bottle of water and a snack
Take wallet and coat in case you don't get a lift home, empty bladder

During transfer:
Wear your seatbelt
Hold patient's wrist to regularly feel temp of skin and pulse volume, most likely traumatic arrest rhythm is going to be PEA
Talk to 999 crew if you start to feel unwell
Don't worry about documentation en route
Prepare for handover to the trauma team
Call MTC if condition changes en route, or if ETA changes more than 15 minutes

More detailed guidance on West Yorkshire MTN Paediatric Transfers can be found here
https://www.wymtn.com/uploads/5/1/8/9/51899421/paediatric_transfer_guidance_v4__final.pdf

More detailed guidance on South Yorkshire MTN Paediatric Transfers can be found here
southyorkshiremtn.nhs.uk/seecmsfile/?id=663

20. Safeguarding and child protection

Safeguarding is everyone's responsibility. This means all professionals involved in delivering Major Trauma Care are responsible for demonstrating *'professional curiosity'* when gathering information to understand and explore what is happening within a family rather than making assumptions or taking a single source of information and accepting it at face value. It involves seeing past the obvious and thinking the unthinkable.
Police recorded 29,405 offences between April 2022 and March 2023 in the UK. This number is rising. There has been a 106% increase in child cruelty and neglect offences in England in the past 5 years. In the last five years in the UK there was an average of 58 child deaths per year by assault or undetermined intent. This means:

- On average, at least one child is killed a week in the UK
- Children under the age of one are the most likely age group to be killed by another person, followed by 16-to-24-year olds
- Child homicides are most commonly caused by the child's parent or step parent

Consider the presentation of the child, their injuries and the story (or absence) carefully. Discuss any cases which are concerning or unusual with the on call Paediatric Consultant. Beyond this, some major trauma presentations should be discussed with the on call paediatric consultant, if concerns are obvious to the team or not:

- Fractures in non-mobile infants (under 1)
- Fall from height (window or roof)
- Fall down stairs in child <3 years of age
- Knife/ gunshot/ 'weapon' injuries
- Electrocution in child <8 years
- Visceral injuries (intra-abdominal/intrathoracic), spinal injuries in the absence of confirmed major trauma
- Injuries resulting from inadequate restraint (e.g. vehicle incidents)
- Concern parents under influence of substances including alcohol
- Submersion injuries (under 8 years, or if concerns about inadequate supervision)

Chapter 6 of Working Together to Safeguard Children 2023 outlines the statutory requirements of organisations to contribute to investigations surrounding the unexpected death of a child, a process known as Sudden Unexpected Death in Childhood (SUDIC) or Infancy (SUDI).

More detailed guidance for recognition, management and treatment of children with suspected physical abuse in South Yorkshire is available here. southyorkshiremtn.nhs.uk/seecmsfile/?id=751

SUDIC (Sudden Unexpected Death in Childhood)

The death of any child under 18 is reviewed by the Child Death Overview Panel (CDOP). There are two components:

- Rapid response comprising an immediate response (in some centres this is subdivided into immediate and urgent responses- delivered by hospital and community staff respectively)
- An overview of deaths in children, undertaken by the Child Death Overview Panel

Follow the local guideline, which will list the actions required, the authorities that need notified, and practical information for the family.

21. Rehabilitation

Rehabilitation is an important part of recovery after major trauma. Most paediatric patients are transferred to the MTC for their acute and ongoing care, and rehabilitation will be led by these centres. Detailed guidance on subsequent rehabilitation after transfer to a MTC is outside the scope of this guideline, but all major trauma patients will be alerted to the MTC Rehabilitation Coordinators who will facilitate the start of a rehab prescription and appropriate onward referrals to relevant therapy and medical services. In some units there will be a designated MT Rehabilitation consultant, in others the oversight of a child's rehabilitation needs will be led by a relevant Specialist Consultant(eg, Neurology Consultant).

Where a child is in a local TU or requiring repatriation from another MTC and in need of rehabilitation, referrals should be made by direct contact with the relevant speciality consultant.

It should be remembered that all patients with major trauma will have rehabilitation needs and even a prompt recovery is made, or ultimate transfer to a MTC is not required these should not be ignored. Communication with the child/young person and their family about potential longer term difficulties, discharge planning to include any referrals to relevant community services and liaison with school is absolutely crucial.

All children admitted to a MTC with rehabilitation needs at discharge will receive a rehabilitation prescription outlining their injuries, treatment and rehabilitation. With parent/carer permission this will be shared with schools to ensure a smooth return to education when the child is fit enough. A follow-up phone call will be offered 2-4 weeks following discharge by the MT Rehab Coordinator to ensure the child or young person is continuing to recover from their injuries, is engaging with local therapy services as needed, and has returned to school. Further advice or support will be provided as needed.

A network directory of paediatric rehabilitation services is currently under review. Useful resources include:
The Child Brain Injury Trust Home - Child Brain Injury Trust
Headway Headway - the brain injury association | Headway
The Children's Trust Brain Injury Hub | The Children's Trust (thechildrenstrust.org.uk)
Back Up Spinal Injuries Charity Back Up Spinal Cord Injury Charity (backuptrust.org.uk)
Spinal Injuries Association We are the expert, guiding voice for life after spinal cord injury - SIA

22. When a child dies – checklist and staff support

The following checklist is a guide to help staff know what to do when a child dies following traumatic injury. This list is not intended to replace local procedures and checklists where they already exist.

SUDIC = Sudden Unexpected Death in Childhood (applies until 18th birthday) and will include all deaths related to trauma and suicide.

For guidance on when to refer a death to the coroner
https://www.gov.uk/after-a-death/when-a-death-is-reported-to-a-coroner

The following should all be documented clearly and legibly, on a local proforma if this is available:

Child and family details		Child's full name, date of birth and gender
		Child's address
		NHS number and Emergency department ID
		Date of admission
		Next of kin including names, addresses, contact details
		Any other significant family member details, including siblings
		First language and whether interpreter required
		School or nursery
Medical responsibilities		Consider organ donation and referral to SNOD (specialist nurse in organ donation) – for more details see NHSBT Organ Donation referral and checklist https://www.odt.nhs.uk/deceased-donation/best-practice-guidance/donor-identification-and-referral/
		Follow local SUDIC procedure and involve a senior paediatrician
		Document time and place of death, and who certified the death
		Document consultant(s) responsible at time of death
		Make Coroner's referral including • Name and grade of doctor who made referral • Name of Coroner's officer and contact details • Details and outcome of discussion
		Issue death certificate if the coroner gives permission • Name of doctor, GMC number, contact details • Cause of death
		Complete Cremation Form if appropriate
		Record police officer name, collar number and contact details
		Consider offering hospital post mortem – if so, arrange for consent
		Inform colleagues previously involved in care of patient
		Inform GP
		Write a formal letter to summarise events leading up to the death, which can be copied to the GP, relevant professionals and the coroner if needed
		If you think you will need to write a statement, complete this in the next week whilst events are fresh in your mind

Nursing responsibilities		Document which nurse(s) involved / present at time of death
		Note any special requests regarding care of child's body / possessions such as clothes and toys
		Organise keepsakes, such as hand and footprints, a lock of hair
		Given written information on bereavement / when a child dies if available
		Make family aware of how to return to see their child after death
		Notify midwife if under 4 weeks old
		Notify health visitor or school nurse depending on age
		Notify local safeguarding team if appropriate
		Notify social care if appropriate
		Identify whether any other agencies involved and notify them
		Identify any local sources of psychology or bereavement support that may be offered to the family
		If you may need to write a statement, complete this in the next week
Leaving the department		Two name bands in situ
		Mortuary card completed
		Mortuary staff informed
		Porters requested
		Update patient information system to record death of the child
		Photocopy all notes and keep them safe

Staff support

The serious injury or death of a child is usually a traumatic event for those involved, including the staff who have looked after the child. After the event, consider holding a meeting inviting all staff involved in the care of the child.

The aims of the meeting should be:

- To review the event and reflect upon what happened
- To provide an opportunity for staff to share their experiences in a safe and supportive environment
- To identify areas of good practice
- To identify any lessons learned
- To identify any further actions that need to be taken, and by whom
- To signpost staff to further support if needed

Staff needing to access further support following an event may do so in the following ways:

1. Individual support from the clinical supervisor / educational supervisor / line manager
2. Referral to the local Occupational Health Service, or local Psychology Service if available
3. Referral to the General Practitioner
4. Referral to professional bodies and unions

https://www.rcn.org.uk/ Your wellbeing (bma.org.uk)
https://www.unison.org.uk/ http://www.medicalprotection.org/uk
http://www.themdu.com/
http://www.yorksandhumberdeanery.nhs.uk/pgmde/pgmde/trainee_support/

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24. Working Group membership

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25. Acknowledgements

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26. Appendices

Appendix 1a

Yorkshire & Humber Regional Paediatric Trauma Guideline for Management of Major Haemorrhage

Paediatric patients <50kg

Clinical picture compatible with Massive Blood Loss

Activate Paediatric Major Haemorrhage Protocol
Early communication with Blood Bank

Secure intravenous access and take blood samples:

- FBC
- Group & Crossmatch
- Coagulation screen
- Near patient testing

Give IV Tranexamic Acid 15mg/kg (max 1g) followed by infusion **Consider use of IV calcium** at the same time if ionised Ca <1.0 **Keep the patient warm**

Transfuse Red Cells and FFP: ratio of 1:1 at 10ml/kg
(Advise Transfusion Lab of Volume Required)

- Fully crossmatched blood when available
- Uncrossmatched ABO group specific when blood group known
- Use uncrossmatched group O Rh D negative only in extreme emergency (where sample is not available) - O RhD positive may be issued for male patients
- **Aim to give all blood products via a blood warming device**

If bleeding continues

Until lab results available

Transfuse Red cells and FFP: ratio 1:1 at 10ml/kg
Consider Platelets at 10-15ml/kg
Consider Cryoprecipitate 10ml/kg

If lab results available

Continue transfusion to achieve

- Hb >80g/l
- Platelets >75x10^9/l
- Fibrinogen >1.5g/l
- APTT/PT <1.5 x midpoint of normal

Continue blood products in the ratios above until bleeding controlled

Complete transfusion documentation to transfer with patient

Appendix 1b Transfusion Transfer Documentation

Please complete this document prior to transfer and attach to patient notes

Patient Details:	Transfer:
Name ……	From ……
DoB ……	To ……
ID Number ……	

Blood transfused prior to transfer or in transit:

Red cells donation numbers:

…… …… ……

…… …… ……

…… …… ……

Platelets donation numbers:

…… …… ……

…… …… ……

…… …… ……

FFP donation numbers:

…… …… ……

…… …… ……

…… …… ……

Appendix 1c - Massive Haemorrhage - additional information

Definitions

These may be difficult to apply in the acute situation. BSH (2015) advise the following:

- Massive blood loss may be defined as either 80 ml/kg in 24 h, 40 ml/kg in 3 h or 2–3 ml/kg/min.
- In clinical practice, the usual triggers are haemodynamic changes compatible with hypovolaemia accompanying evidence or suspicion of serious haemorrhage
- A senior doctor (middle grade or above) authorises its use to ensure that scarce blood component resources are used appropriately.
- Normal paediatric blood volume ranges from 70-80ml/kg

Communication with the Transfusion Lab

Successful treatment of massive blood loss depends on prompt action, good communication and involvement of senior clinicians with the necessary expertise.

- Pre-alert the Transfusion Lab if time allows.
- Give patient details and request the Major Haemorrhage Pack.
- Ensure a correctly labelled patient ID wristband is in place detailing the patient's NHS number as the primary identifier.
- Send a correctly labelled transfusion sample to the Transfusion Lab. There is a zero-tolerance approach to mislabelled samples, and incorrectly labelled samples will lead to a delay in the provision of blood and blood components
- Take samples for FBC, clotting screen and urea and electrolytes

For patients with active bleeding use a restrictive approach to volume resuscitation until definitive early control of bleeding has been achieved. Administer red cells and FFP in a 1:1 ratio in 10ml/kg aliquots.

- Any unused blood components MUST be returned to blood bank immediately
- If red cells arrive in a cool box it should be kept in the cool box in which it arrives for up to the maximum length of time stated on the transport slip.
- Each blood unit should be removed and used one at a time, between each removal ensure the lid is securely positioned on the cool box at all times. Platelets must not be stored in the cool box.

Red Cells	**It is preferable to use fully cross matched blood or type specific where available but if necessary O negative should be used if to delay would be harmful**	
	Extreme urgency - immediate transfusion	Group O Rh negative red cells should only be used if the doctor feels that a delay of only 5 to 10 minutes would endanger the patient's life
	Very urgent - grouped but uncrossmatched	Uncrossmatched blood of a compatible ABO group can be provided within 15 minutes of receiving a sample and a warning telephone call
	Urgent - emergency crossmatch	The procedure for an emergency crossmatch may be completed in a minimum of 40 minutes from receipt of sample

Fresh frozen plasma (FFP)	• FFP must be thawed before use: a process which takes up to 40 minutes, therefore clear and pre-emptive communication with the laboratory is important • FFP issued may be methylene blue (MBFFP) or octaplasLG • If fibrinogen levels remain critically low (<1.5g/l) cryoprecipitate therapy should be considered
Platelets	• Communicate early with the Blood Bank Laboratory to highlight requirement for platelets. Be aware of stock levels within the hospital. • Order 20 ml/kg platelets after 50% blood volume has been transfused (40 ml/kg if there is ongoing blood loss) • The standard dose is 10 ml/kg • Transfusion is recommended once a level of 75 x 10^9 per litre is reached in acutely bleeding paediatric patients; this level can be anticipated when approximately two blood volumes have been replaced by fluid or red cell components (earlier if DIC occurs) • Transfusion is recommended once a level of 100 x 10^9 per litre is reached in those with multiple high energy trauma, those with central nervous system injury, or if platelet function is known to be abnormal
Cryoprecipitate	• Cryoprecipitate must be thawed before use: a process which takes up to 40 minutes so be aware of timings • Aim to maintain fibrinogen levels >1.5 g/l • Two units of cryoprecipitate provides 3.2 – 4g fibrinogen in a volume of 150-200mls • Administer as per clinical condition at 10ml/kg; cryoprecipitate is available in pooled and single units. One pooled unit contains 5 single units.
Tranexamic acid	• Give IV tranexamic acid 15mg/kg (max 1g) within 3 hours, followed by a maintenance dose of 2mg/kg/hour over the next 8 hours.

Do not wait for blood results but be guided by the clinical assessment of the on-going need for blood component resuscitation.

Transfer of blood products and components between hospitals

- Contact the lab and request blood for transfer; confirm who will organise appropriate documentation and storage requirements
- Blood products and components being transferred with a patient to another hospital must:
    - be packaged appropriately
    - have transit documentation completed (appendix)
    - have a transport label on the outside of the transfer box
- DO NOT send blood from the clinical area
- All blood products and components are stored under conditions which ensure that they remain safe to use therefore adherence to Blood Quality Management is essential
    - Upon arrival at the receiving hospital any blood products/components that are not being transfused and are not immediately required must be **delivered to the blood bank** as soon as possible
    - The Transfusion lab staff will re-issue the products/components once they are satisfied that they are safe to use
    - Please inform the Transfusion Laboratory at the receiving hospital if the patient has received any blood products/components.

Appendix 2a

Child with major traumatic injury – drugs for emergency anaesthesia in the ED

INDUCTION AGENT
Fentanyl 0-3 microgram/kg plus
Ketamine 1-2mg/kg

→ Use lower dose range if cardiovascularly unstable. Ketamine can be used in traumatic brain injury.

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

→ Avoid suxamethonium in
- Renal failure
- Rhabdomyolysis
- Burns >12 hours
- High spinal cord injuries >12 hours

CONTINUED SEDATION
Morphine 20-80 microgram/kg/hour and
Midazolam 120-360 microgram/kg/hour

OR
Propofol 2-5mg/kg/hour

→ Consider propofol if cardiovascularly stable and expected to be woken in a few hours

CONTINUED MUSCLE RELAXATION
Rocuronium boluses 1mg/kg
or infusion
300-600microgram/kg/hour

Appendix 2b

Paediatric Trauma Intubation Checklist

For team leader to use before every trauma intubation

Team

Allocate roles

- Intubator
- Assistant
- Cricoid
- MILS
- Drugs
- Confirm plan and rescue plan
- Call for help if difficulty anticipated

Patient

- Optimise haemodynamics
- Optimise preoxygenation
- Optimise patient position and trolley height
- Optimise AAGBI monitoring. BP on 2 min cycle away from IV and SpO_2 monitor

Drugs

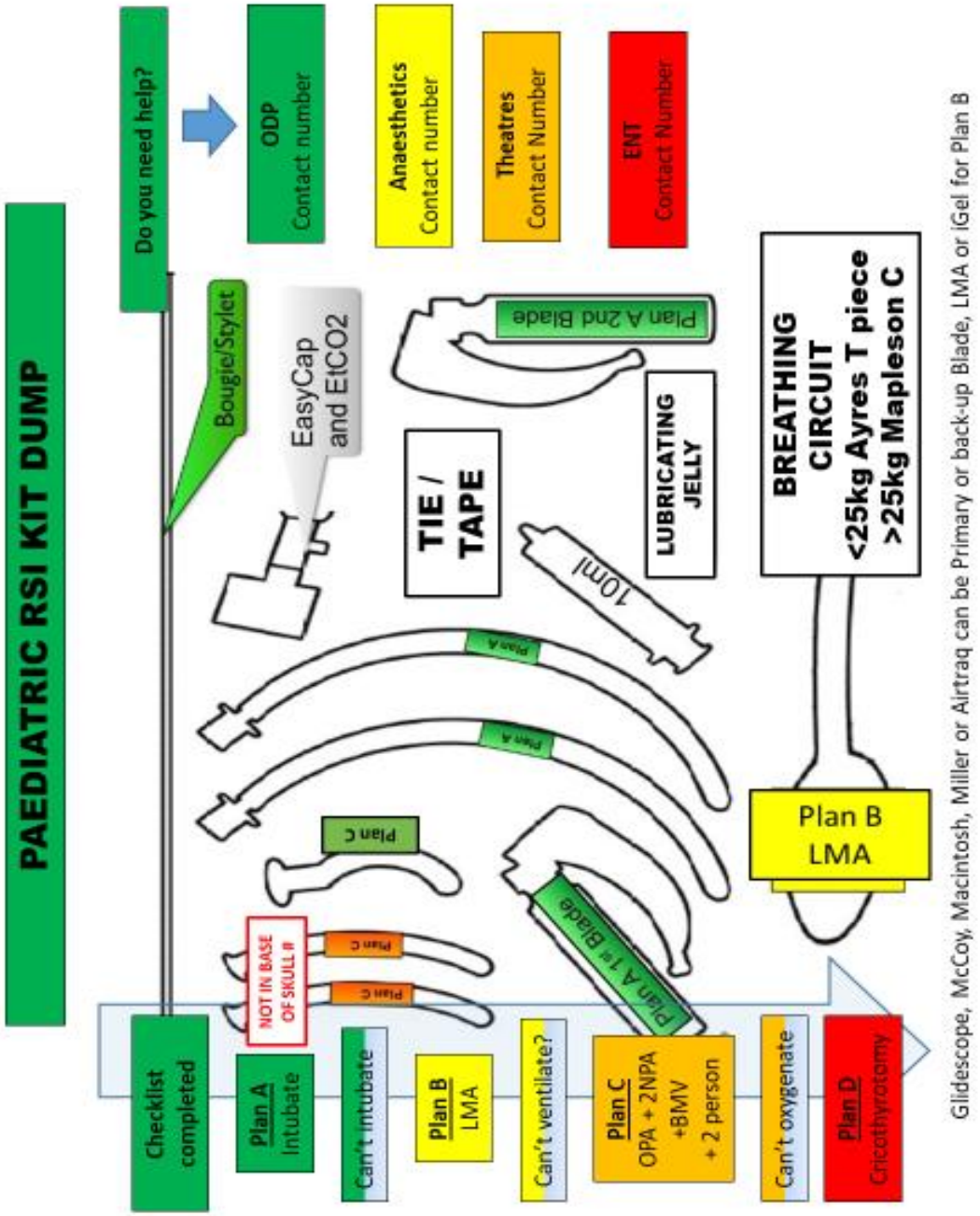
- Secure IV/IO access
- Induction drug and relaxant dose drawn up
- Emergency drugs
- Saline flushes
- Fluid bolus
- Post intubation sedation/relaxant/analgesia

Equipment

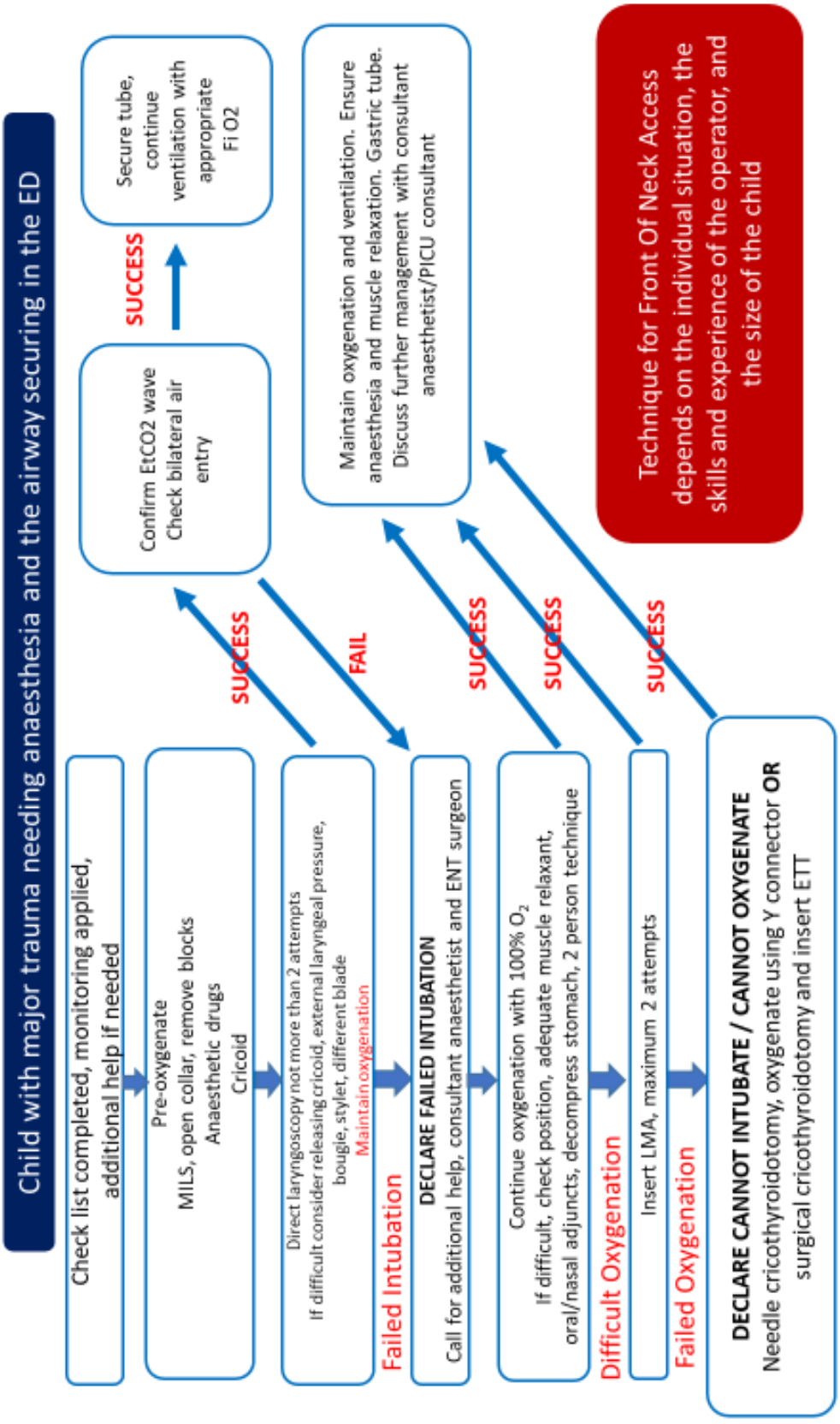
- Airway equipment checklist complete
- Suction working
- NG tube and syringe
- Stethoscope
- Ventilator
- Difficult airway equipment

- Steph Bew April 2017

Appendix 2c


PAEDIATRIC RSI KIT DUMP
Do you need help?
ODP
Contact number
Anaesthetics
Contact number
Theatres
Contact Number
ENT
Contact Number
Bougie/Stylet
EasyCap
and EtCO2
Plan A 2nd Blade
TIE /
TAPE
LUBRICATING
JELLY
10ml
BREATHING
CIRCUIT
<25kg Ayres T piece
>25kg Mapleson C
Plan A
Plan A
Plan C
NOT IN BASE
OF SKULL #
Plan C
Plan C
Plan A 1st Blade
Plan B
LMA
Checklist
completed
Plan A
Intubate
Can't intubate
Plan B
LMA
Can't ventilate?
Plan C
OPA + 2NPA
+BMV
+ 2 person
Can't oxygenate
Plan D
Cricothyrotomy
Glidescope, McCoy, Macintosh, Miller or Airtraq can be Primary or back-up Blade, LMA or iGel for Plan B

Appendix 2d

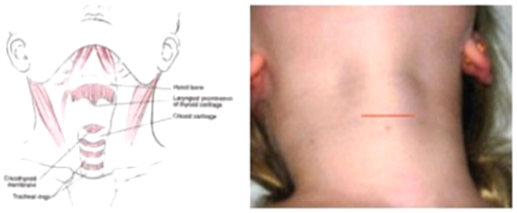

Child with major trauma needing anaesthesia and the airway securing in the ED
Check list completed, monitoring applied, additional help if needed
Pre-oxygenate
MILS, open collar, remove blocks
Anaesthetic drugs
Cricoid
Direct laryngoscopy not more than 2 attempts
If difficult consider releasing cricoid, external laryngeal pressure, bougie, stylet, different blade
Maintain oxygenation
Failed Intubation
DECLARE FAILED INTUBATION
Call for additional help, consultant anaesthetist and ENT surgeon
Continue oxygenation with 100% O2
If difficult, check position, adequate muscle relaxant, oral/nasal adjuncts, decompress stomach, 2 person technique
Difficult Oxygenation
Insert LMA, maximum 2 attempts
Failed Oxygenation
DECLARE CANNOT INTUBATE / CANNOT OXYGENATE
Needle cricothyroidotomy, oxygenate using Y connector OR surgical cricothyroidotomy and insert ETT
SUCCESS
FAIL
SUCCESS
SUCCESS
SUCCESS
SUCCESS
Confirm EtCO2 wave
Check bilateral air entry
Secure tube, continue ventilation with appropriate Fi O2
Maintain oxygenation and ventilation. Ensure anaesthesia and muscle relaxation. Gastric tube. Discuss further management with consultant anaesthetist/PICU consultant
Technique for Front Of Neck Access depends on the individual situation, the skills and experience of the operator, and the size of the child

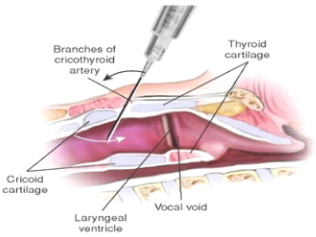
Appendix 2e and 2f

Needle Cricothyroidotomy

Equipment Required
- ❑ 16G IV cannula
- ❑ 5ml syringe containing 2ml saline
- ❑ Oxygen tubing + Y connector
- ❑ Rolled towel for under the child's shoulders

Surface markings



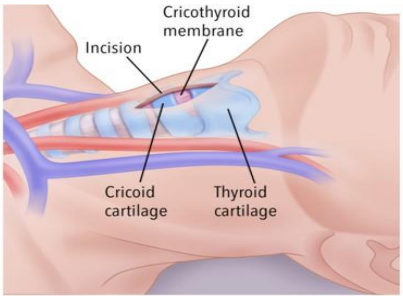


Procedure (NB: written for right-handed operator)

- Patient anaesthetised and paralysed
- Place patient in supine position with a large shoulder roll to extend the neck
- Stand on the child's left and locate the cricothyroid membrane
- Attach a 5ml syringe containing 2ml saline to the cannula
- Immobilise the trachea with your left finger and thumb
- Insert the cannula through the cricothyroid membrane then aim 45º downwards towards the feet. STAY IN THE MIDLINE
- Aspirate continuously. When you aspirateair the needle is in the trachea
- Immobilise the syringe DONT PULL BACK and slide the cannula down the needle into the trachea
- Recheck air can still be aspirated from the cannula
- Attach O_2 tubing on to the cannula
- Run O_2 at 1 litre/min per year of age
- Occlude the side hole of the Y connector for 1 sec, then release for 4 sec to allow expiration
- If this does not cause the chest to rise increase the oxygen flow rate in 1L increments until chest movement is seen
- Check neck to exclude swelling from injection of gas into the subcutaneous tissues
- Secure cannula and continue ventilation
- Prepare for tracheostomy

Surgical Cricothyroidotomy

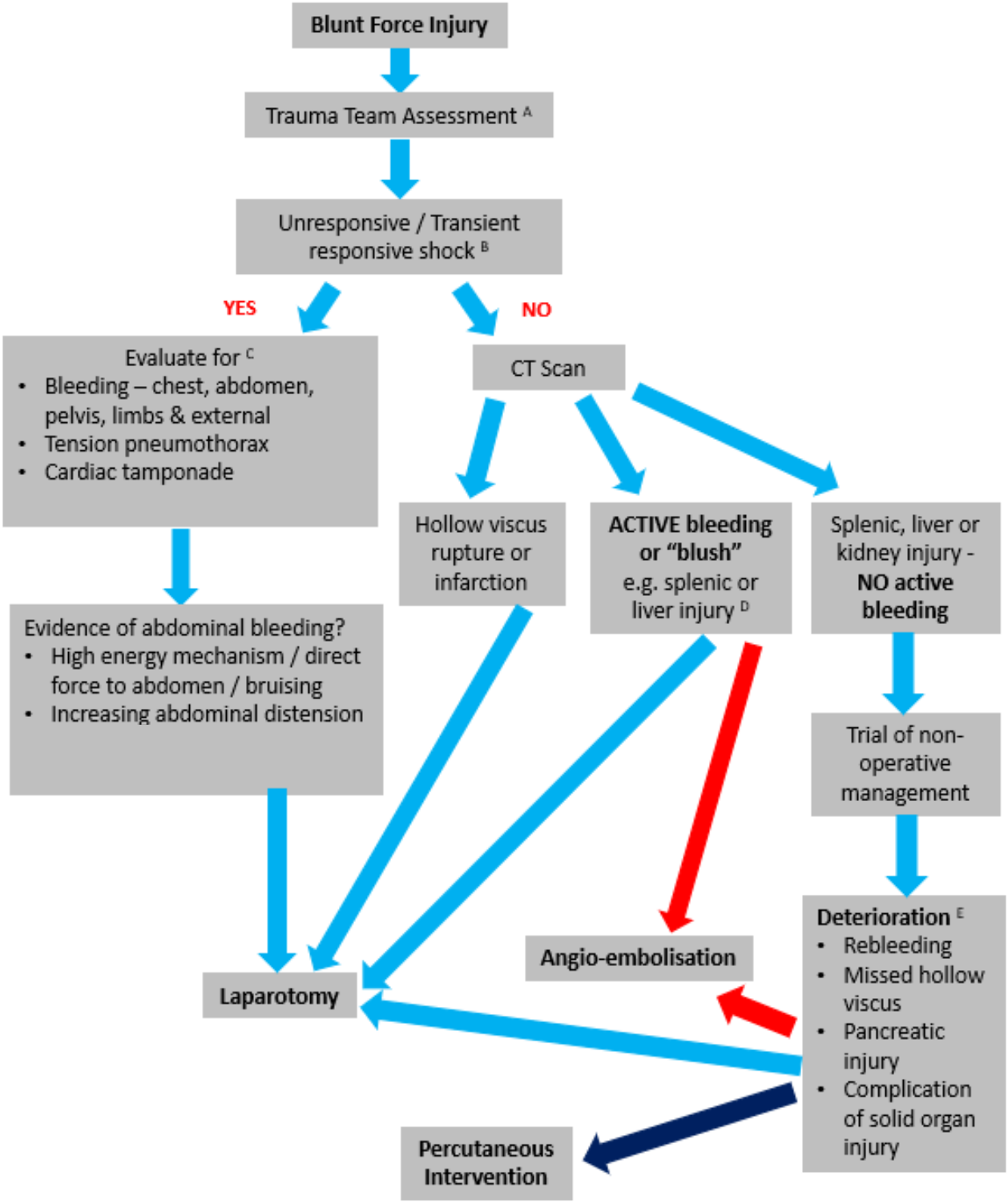
Equipment required
- ❑ Scalpel with number 10 blade
- ❑ Bougie (5,8,11Fr to fit a range of tubes)
- ❑ Appropriate sized ET tube (3.0,4.0, 5.0 cuffed tubes preferable
- ❑ Breathing circuit / Ambu bag
- ❑ Rolled towel for under child's shoulders



Procedure (NB: written for right-handed operator)

- Patient anaesthetised and paralysed
- Place patient in supine position with a large roll under the shoulders to extend the neck
- Stand on the child's left and locate the cricothyroid membrane
- Immobilise the trachea with your left finger and thumb
- Make a VERTICAL incision in the skin (to avoid blood vessels) Bluntly dissect the subcutaneous tissues with your finger
- Palpate the cricothyroid membrane. Make a HORIZONTAL incision through it.
- Insert the handle of the scalpel through the incision and twist through 90º to open the airway
- Insert bougie
- Railroad an appropriately sized tracheal tube. Use a slightly smaller tube than would be used for an oral intubation
- Attach breathing circuit with capnography and confirm effective ventilation
- Secure the tube to prevent dislodgement and continue ventilation

Appendix 3a - Management algorithm for blunt abdominal injury



Appendix 3a - KEY

A. Abdominal examination should be included within assessment of "C" as a potential source of bleeding

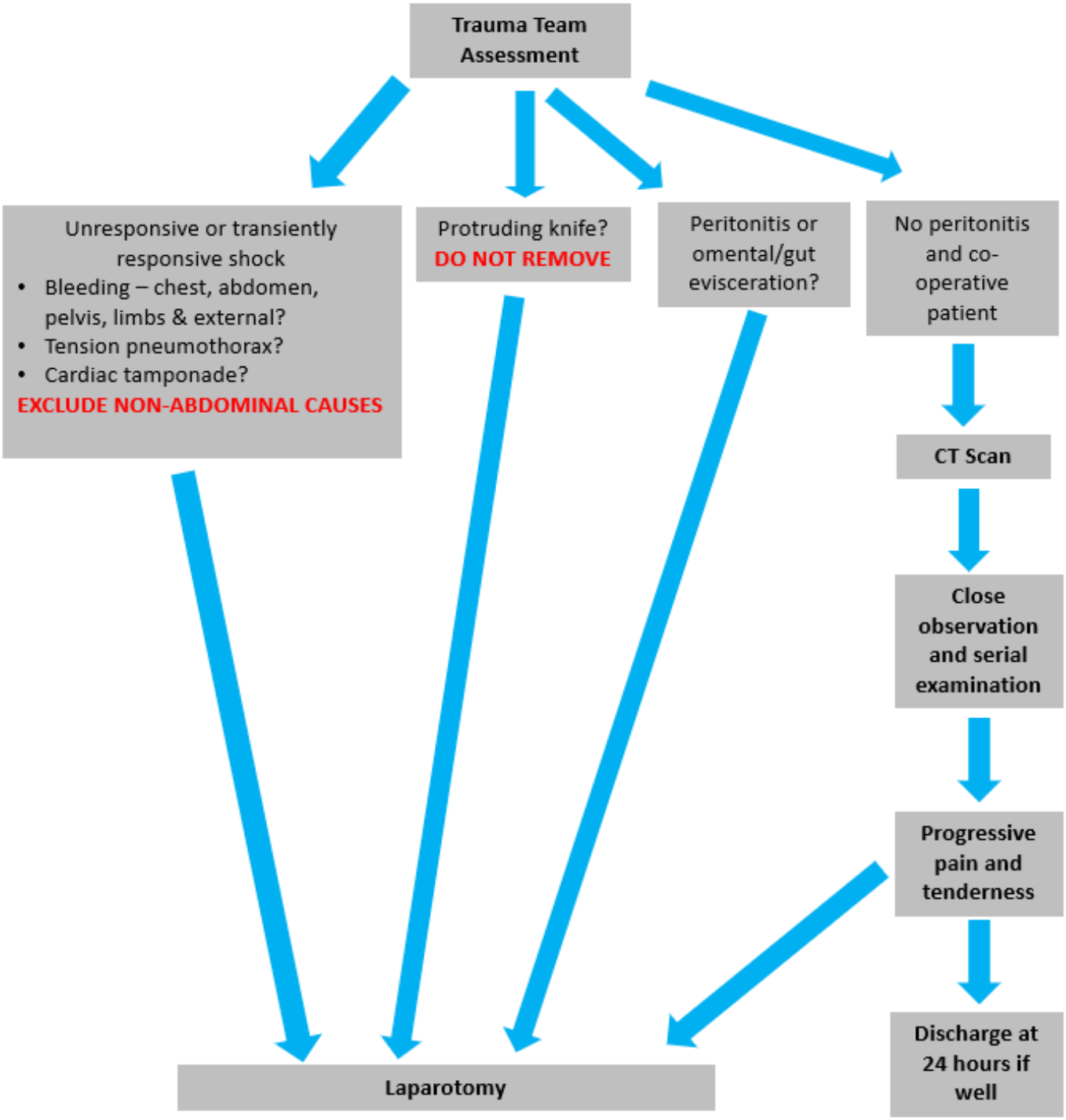
B. Senior decision makers (Consultant Paediatric Surgeon or equivalent in TU) / Consultant in Emergency Medicine/Consultant Paediatric/Interventional Radiologist) to assess and decide if patient's hemodynamic status is deteriorating too fast to proceed to CT.

C. Unresponsive or transiently responsive shock is usually due to bleeding. Potential sites (chest, abdomen, pelvis, limbs and external loss) of bleeding should be evaluated. Obstructive / mechanical causes of shock (tension pneumothorax and cardiac tamponade) should also be considered. Rarer causes of shock include myocardial contusion, neurogenic shock, myocardial infarction and air embolus. Non-abdominal sources of shock will need intervention in parallel with intra-abdominal assessment and intervention e.g. chest drain, pelvic binder, wound compression etc.

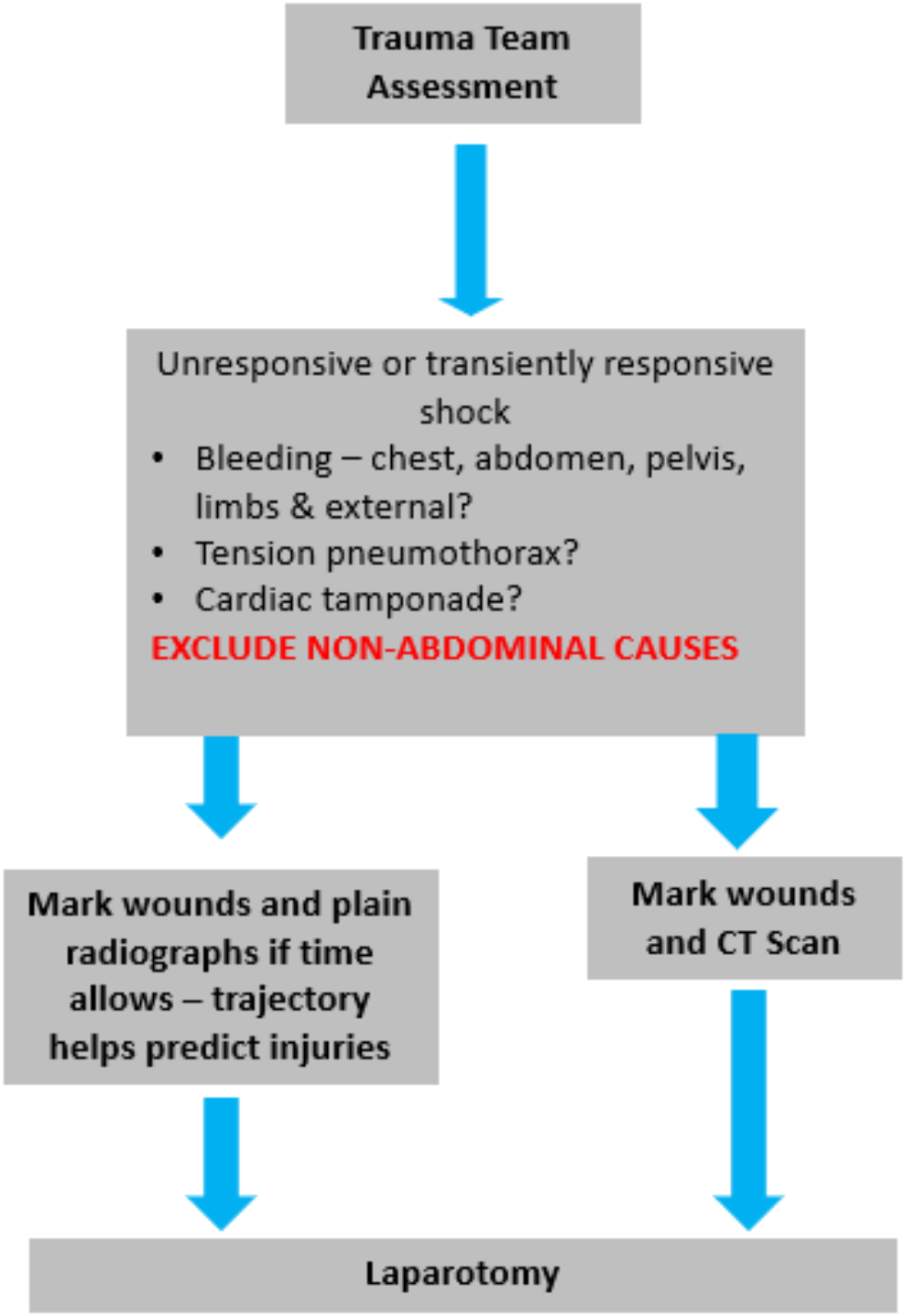
D. If bleeding or "blush" reported on CT scan a discussion between paediatric surgical team and radiological team is required to clarify precise nature of abnormality detected. Evidence of bleeding in to peritoneal cavity will almost certainly require intervention. Contained blush within a solid organ may not. If evidence of active bleeding and hemodynamic deterioration, requires discussion between Consultant Paediatric Surgeon (or equivalent in TU) and Paediatric/Interventional Radiologist to determine suitability for embolisation or laparotomy. Factors to consider include rate of hemodynamic deterioration, constellation of injuries and physiological reserve. If embolization felt to be appropriate this may necessitate transfer to Leeds.

E. Patients undergoing a trial of non-operative management require regular clinical assessment and hemoglobin measurements ideally initially within a critical care environment. Evidence of hemodynamic deterioration, falling hemoglobin, coagulopathy, increasing abdominal pain or tenderness or rising inflammatory markers requires discussion with the Consultant Paediatric Surgeon. Depending on the rate of deterioration and clinical suspicion, the patient should undergo CT imaging or more rarely emergency transfer to theatre. The CT scan may reveal re-bleeding, missed hollow viscus injury, pancreatic injury or complication of known solid organ injury. Further bleeding may be treated with embolization or surgery determined by hemodynamic deterioration, constellation of injuries and physiological reserve. Missed injuries or complications may require a combination of radiological or surgical intervention depending on the exact diagnosis.

Appendix 3b - Management algorithm for penetrating stab injury



Appendix 3c – Management algorithm for gunshot injury



Appendix 4a

Severe Traumatic Brain Injury Pathway (GCS 8 or less)

A

Intubate and ventilate with cervical spine control
- Oral endotracheal tube
- C-spine immobilization

B

Avoid desaturation
- Monitor end tidal CO_2, aim to correlate $PaCO_2$ 4.5-5.3 kPa
- Monitor saturations (aim >95%) and PaO_2 aim >13kPa

C

Avoid Hypotension
- Do not delay CT for arterial/central access
- Consider blood after 20ml/kg fluid boluses
- Target mean arterial blood pressure by age (Box 4)
- Dopamine or noradrenaline if needed to maintain BP

Consider Tranexamic Acid – Appendix 4b. Tranexamic acid algorithm

D

In the child with severe multiple trauma, consider immediate transfer to MTC without scan

CT brain and cervical spine within 30 minutes
- Institute neuroprotective measures (Box 2)
- Management of raised ICP (Box 3)
- Urgent neurosurgical referral to Major Trauma Centre
- Prepare for time critical transfer by local team

Time critical injury on CT

North Yorkshire & Humberside Major Trauma Network

Call Embrace 0114 305 8200 select TRAUMA option

Paediatric Neurosurgery Leeds (for patients from York, Scarborough and Hull) on call registrar mobile 07979 928120

Paediatric Neurosurgery Sheffield (for patients from NLAG sites) via switchboard 0114 271 7000 bleep 174

West Yorkshire Major Trauma Network

Call Embrace 0114 305 8200 select TRAUMA option

Paediatric Neurosurgery Leeds on call registrar mobile 07979 928120

South Yorkshire Major Trauma Network

Call Embrace 0114 305 8200 select TRAUMA option

Paediatric Neurosurgery Sheffield via switchboard 0114 271 7000 bleep 174

1. Signs of critically raised ICP

Unequal or unreactive pupils

Bradycardia or hypertension

Decorticate or decerebrate posturing

GCS <8, responding to pain only or unresponsive

Bulging fontanelle

Seizures

2. Neuroprotective measures

Avoid desaturation

Avoid hypotension (Box 4)

Sedate and muscle relax

30 degrees head up

Head in midline

Normothermia

Normoglycaemia

Keep Na>135 mmol/l

Phenytoin 20mg/kg

Avoid neck lines

3. Management of raised ICP

Ensure fully sedated and muscle relaxed

Hyperventilate to a $PaCO_2$ of 4.0-4.5 kPa

Maintain mean blood pressure to age specific targets (Box 4)

Osmotic therapy - either 3% hypertonic saline 3ml/kg or mannitol 0.5g/kg (will need urine catheter)

Aim temperature 36-37°C

4. Maintain mean arterial blood pressure (MAP)

Ensure adequate cerebral perfusion pressure
CPP = MAP – ICP

Age	MAP
<1 year	>60
1-2 years	>65
3-5 years	>70
6-10 years	>75
>10 years	>80

Appendix 4b

Tranexamic Acid Use in Paediatric Patients with Isolated Head Injuries

Isolated Head Injury in a Child Under 16 Years Old?

YES

NO

Leave this pathway
Use the TXA in paediatric major trauma guidelines to see if TXA indicated for the patient
If after imaging an isolated head injury is confirmed, rejoin this guideline to see if the patient is eligible for TXA

*** GCS 12 or less?**
*** Isolated Head injury?**
*** Injury in last 2 hours?**

No to one or more questions - Don't give TXA

Yes to all three questions = Give TXA immediately
(see box 1 and 2)

CT head completed ASAP where indicated
Does the CT show a Traumatic Brain Injury?*

NO

TXA bolus should not be given or stopped if not already completed

YES
Is it less than 2 hours since injury still?

If yes to BOTH questions give TXA (see box 1 and 2)

If >2 hours since injury, discuss TXA admin with neurosurgery

Box 1. Tranexamic acid (TXA) doses.

15mg/kg (up to a maximum of 1g) intravenous bolus injection of tranexamic acid

Box 2. Special considerations for the administration of TXA:

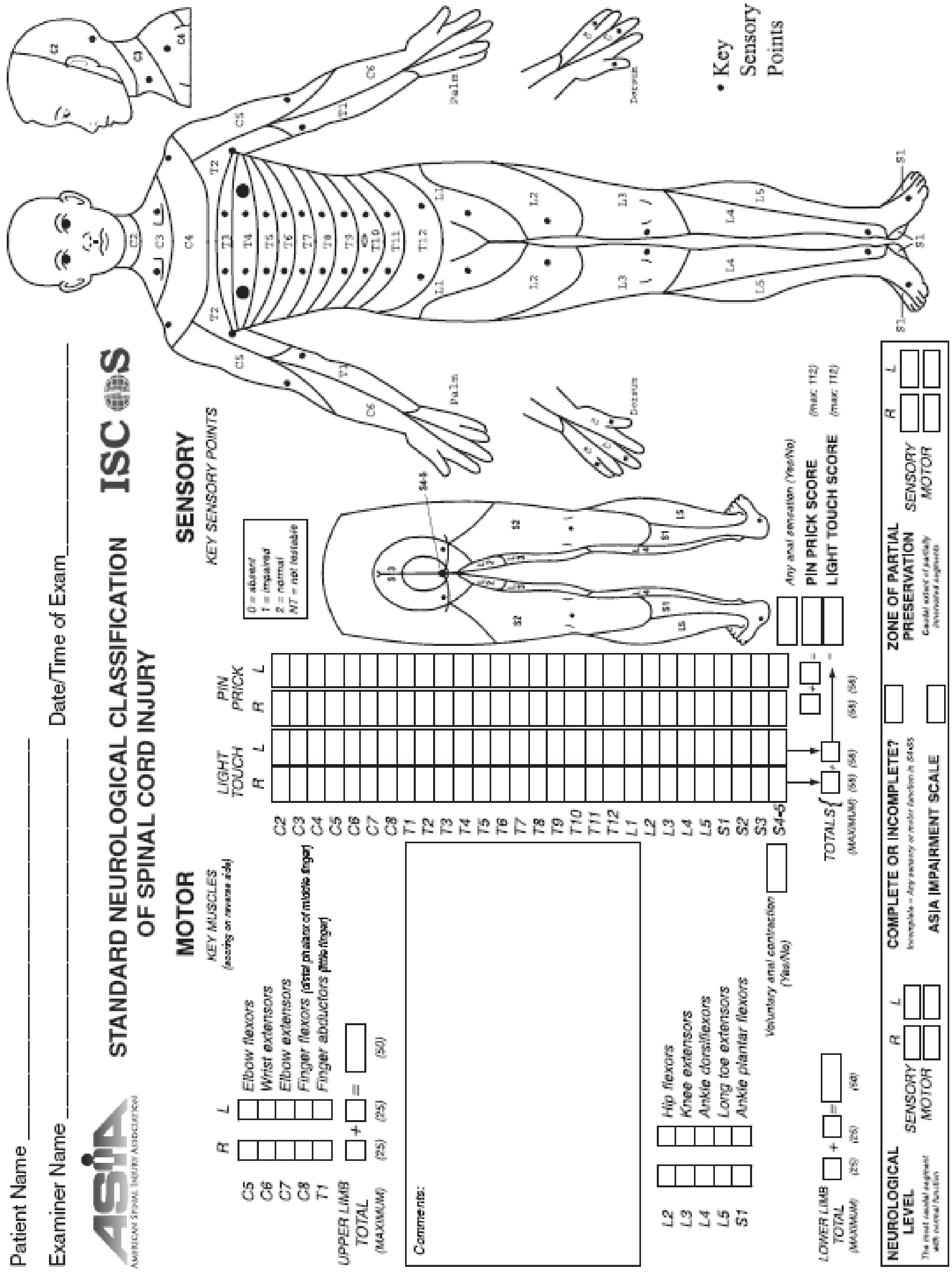
Consultant decision under 1 year old

Caution with children with metabolic conditions and a confirmed procoagulant state e.g. hereditary thrombophillia or previous VTE

*** Does the CT show a TBI?**
Traumatic Brain Injury is a clinical diagnosis based on GCS. For the purpose of this guideline, TBI on a CT scan refers to intracranial haemorrhage.

References https://www.wymtn.com/crash-3.html, https://www.nice.org.uk/guidance/ng232/chapter/recommendations#tranexamic-acid
Authors: Dr. Eleanor Clegg, Dr. Amelia Stacey, Mr John Goodden, Dr Alia Yaqub May 2024

Appendix 5



Patient Name ______________________

Examiner Name ______________________ Date/Time of Exam ______________

AMERICAN SPINAL INJURY ASSOCIATION

STANDARD NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

ISCoS

MOTOR

KEY MUSCLES (scoring on reverse side)

	R	L	
C5			Elbow flexors
C6			Wrist extensors
C7			Elbow extensors
C8			Finger flexors (distal phalanx of middle finger)
T1			Finger abductors (little finger)

UPPER LIMB TOTAL (MAXIMUM) ☐ + ☐ = ☐ (25) (25) (50)

Comments:

	R	L	
L2			Hip flexors
L3			Knee extensors
L4			Ankle dorsiflexors
L5			Long toe extensors
S1			Ankle plantar flexors

Voluntary anal contraction (Yes/No) ☐

LOWER LIMB TOTAL (MAXIMUM) ☐ + ☐ = ☐ (25) (25) (50)

SENSORY

KEY SENSORY POINTS

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

TOTALS (MAXIMUM) (56) (56) (56) (56)

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

Any anal sensation (Yes/No) ☐

PIN PRICK SCORE (max: 112)

LIGHT TOUCH SCORE (max: 112)

• Key Sensory Points

Palm

Dorsum

NEUROLOGICAL LEVEL — The most caudal segment with normal function — SENSORY R L, MOTOR R L

COMPLETE OR INCOMPLETE? — Incomplete = Any sensory or motor function in S4-S5

ASIA IMPAIRMENT SCALE

ZONE OF PARTIAL PRESERVATION — Caudal extent of partially innervated segments — SENSORY R L, MOTOR R L

Muscle Function Grading

0 = total paralysis

1 = palpable or visible contraction

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

3 = active movement, full ROM against gravity

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

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

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

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

Sensory Grading

0 = Absent

1 = Altered, either decreased/impaired sensation or hypersensitivity

2 = Normal

NT = Not testable

When to Test Non-Key Muscles:

In a patient with an apparent AIS B classification, non-key muscle functions more than 3 levels below the motor level on each side should be tested to most accurately classify the injury (differentiate between AIS B and C).

Movement	Root level
Shoulder: Flexion, extension, abduction, adduction, internal and external rotation **Elbow:** Supination	**C5**
Elbow: Pronation **Wrist:** Flexion	**C6**
Finger: Flexion at proximal joint, extension. **Thumb:** Flexion, extension and abduction in plane of thumb	**C7**
Finger: Flexion at MCP joint **Thumb:** Opposition, adduction and abduction perpendicular to palm	**C8**
Finger: Abduction of the index finger	**T1**
Hip: Adduction	**L2**
Hip: External rotation	**L3**
Hip: Extension, abduction, internal rotation **Knee:** Flexion **Ankle:** Inversion and eversion **Toe:** MP and IP extension	**L4**
Hallux and Toe: DIP and PIP flexion and abduction	**L5**
Hallux: Adduction	**S1**

ASIA Impairment Scale (AIS)

A = Complete. No sensory or motor function is preserved in the sacral segments S4-5.

B = Sensory Incomplete. Sensory but not motor function is preserved below the neurological level and includes the sacral segments S4-5 (light touch or pin prick at S4-5 or deep anal pressure) AND no motor function is preserved more than three levels below the motor level on either side of the body.

C = Motor Incomplete. Motor function is preserved at the most caudal sacral segments for voluntary anal contraction (VAC) OR the patient meets the criteria for sensory incomplete status (sensory function preserved at the most caudal sacral segments (S4-S5) by LT, PP or DAP), and has some sparing of motor function more than three levels below the ipsilateral motor level on either side of the body.
(This includes key or non-key muscle functions to determine motor incomplete status.) For AIS C – less than half of key muscle functions below the single NLI have a muscle grade ≥ 3.

D = Motor Incomplete. Motor incomplete status as defined above, with at least half (half or more) of key muscle functions below the single NLI having a muscle grade ≥ 3.

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

Using ND: To document the sensory, motor and NLI levels, the ASIA Impairment Scale grade, and/or the zone of partial preservation (ZPP) when they are unable to be determined based on the examination results.

INTERNATIONAL STANDARDS FOR NEUROLOGICAL CLASSIFICATION OF SPINAL CORD INJURY

Steps in Classification

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

1. Determine sensory levels for right and left sides.
The sensory level is the most caudal, intact dermatome for both pin prick and light touch sensation.

2. Determine motor levels for right and left sides.
Defined by the lowest key muscle function that has a grade of at least 3 (on supine testing), providing the key muscle functions represented by segments above that level are judged to be intact (graded as a 5).
Note: in regions where there is no myotome to test, the motor level is presumed to be the same as the sensory level, if testable motor function above that level is also normal.

3. Determine the neurological level of injury (NLI)
This refers to the most caudal segment of the cord with intact sensation and antigravity (3 or more) muscle function strength, provided that there is normal (intact) sensory and motor function rostrally respectively.
The NLI is the most cephalad of the sensory and motor levels determined in steps 1 and 2.

4. Determine whether the injury is Complete or Incomplete.
(i.e. absence or presence of sacral sparing)
*If voluntary anal contraction = **No** AND all S4-5 sensory scores = **0** AND deep anal pressure = **No,** then injury is **Complete.***
*Otherwise, injury is **Incomplete.***

5. Determine ASIA Impairment Scale (AIS) Grade:

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

NO ↓

Is injury Motor Complete? **If YES, AIS=B**

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

Are at least half (half or more) of the key muscles below the neurological level of injury graded 3 or better?

NO ↓ **AIS=C**

YES ↓ **AIS=D**

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

Appendix 6

Management of significant bleeding from a limb and use of tourniquets

APPLY DIRECT PRESSURE WITH DRESSING AND ELEVATE THE LIMB

SUCCESSFUL?
Apply pressure dressing and continue assessment of patient
Observe wound closely for recurrence of bleeding

UNSUCCESSFUL?
Call orthopaedic and (if available) vascular surgeon
Apply indirect pressure to proximal artery

UNSUCCESSFUL?
Apply tourniquet using pneumatic cuff in preference to Combat Application Tourniquet (CAT)
Apply to **single long bones, or on the lower leg or forearm**

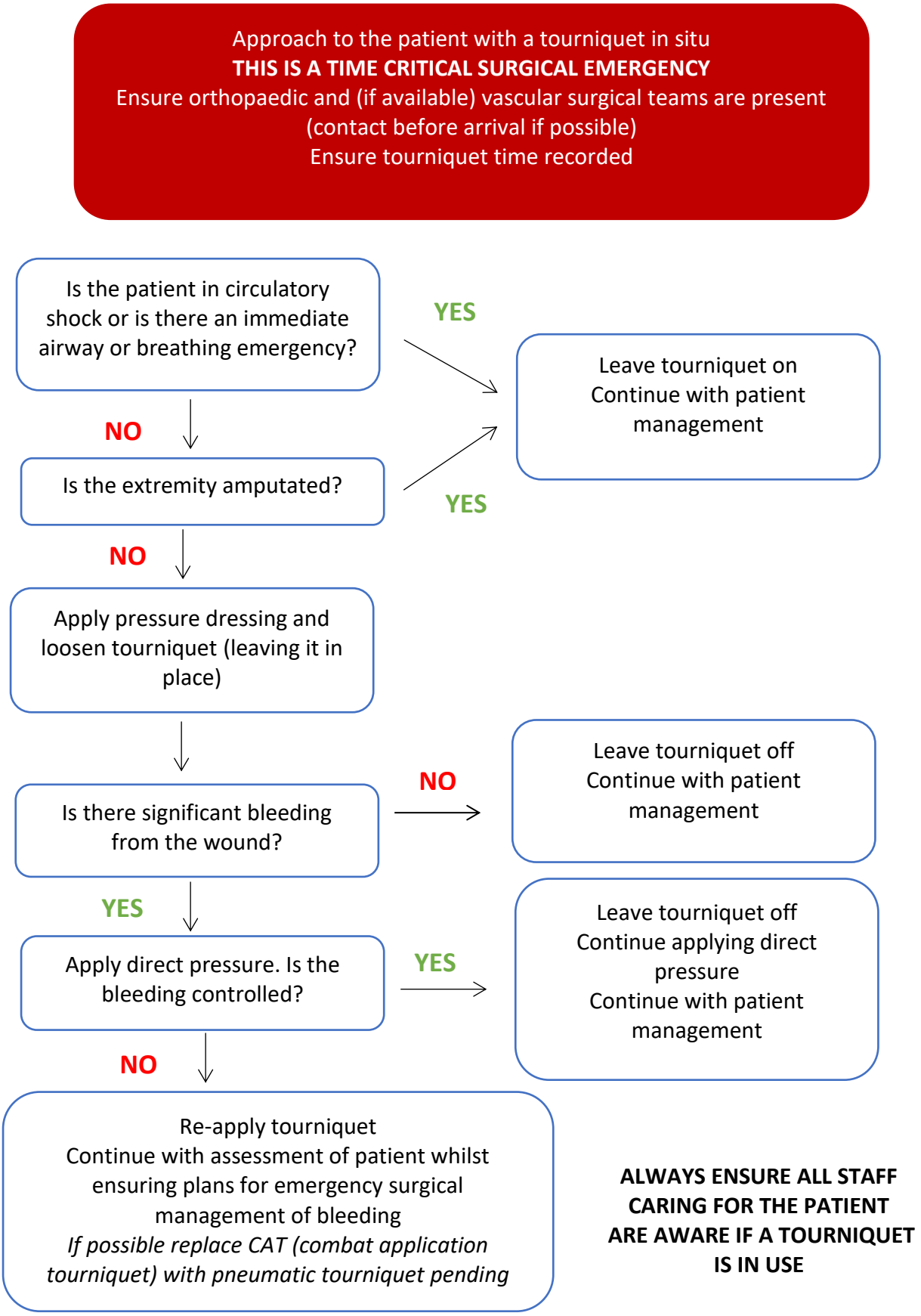
- For the femur, one hand width above the patella or at least 5cm proximal to the wound
- For the humerus, one hand width above the elbow joints or at least 5cm proximal to the wound
- For the lower leg or forearm, 5cm proximal to the wound

THIS IS NOW A TIME CRITICAL EMERGENCY

Record tourniquet time
Ensure presence of suitably senior surgical teams (transferring to MTC if necessary)

ALWAYS ENSURE ALL STAFF CARING FOR THE PATIENT

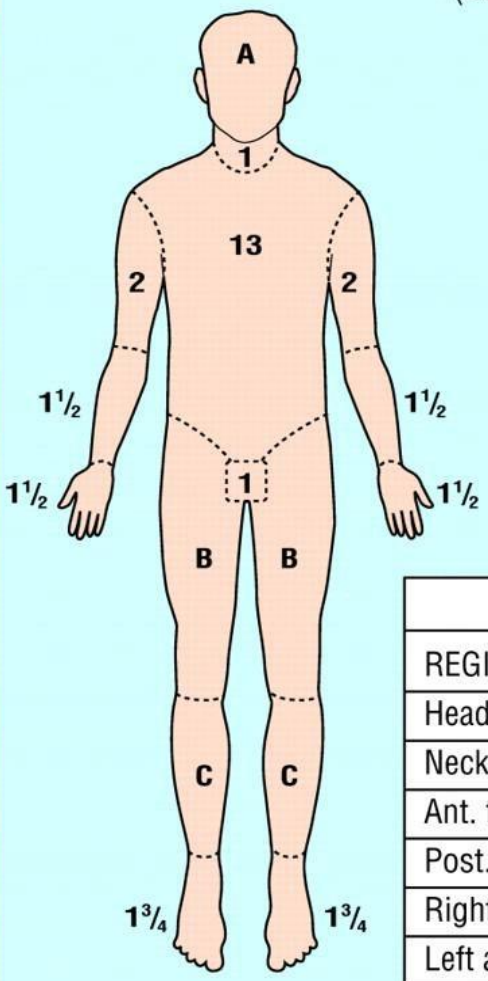
ARE AWARE IF A TOURNIQUET IS IN USE

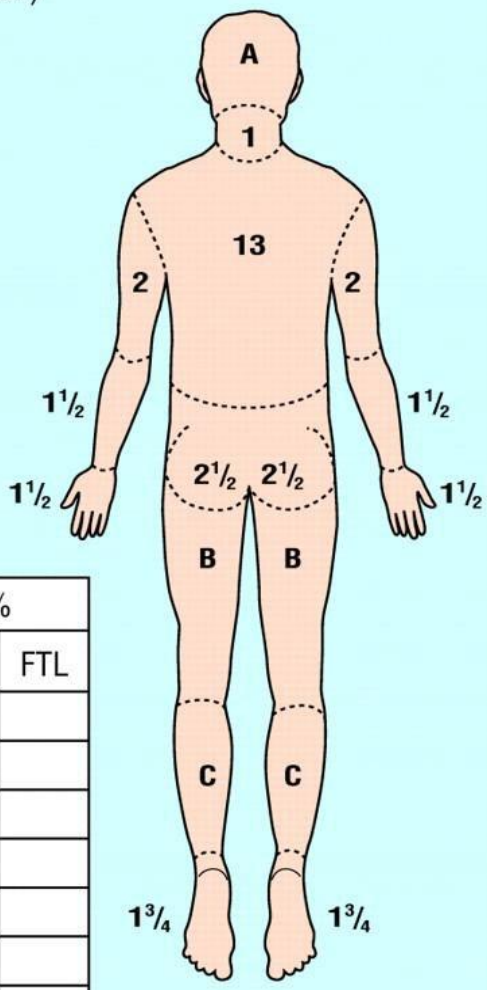

Approach to the patient with a tourniquet in situ
THIS IS A TIME CRITICAL SURGICAL EMERGENCY
Ensure orthopaedic and (if available) vascular surgical teams are present (contact before arrival if possible)
Ensure tourniquet time recorded
Is the patient in circulatory shock or is there an immediate airway or breathing emergency?
YES
Leave tourniquet on
Continue with patient management
NO
Is the extremity amputated?
YES
NO
Apply pressure dressing and loosen tourniquet (leaving it in place)
Is there significant bleeding from the wound?
NO
Leave tourniquet off
Continue with patient management
YES
Apply direct pressure. Is the bleeding controlled?
YES
Leave tourniquet off
Continue applying direct pressure
Continue with patient management
NO
Re-apply tourniquet
Continue with assessment of patient whilst ensuring plans for emergency surgical management of bleeding
If possible replace CAT (combat application tourniquet) with pneumatic tourniquet pending
ALWAYS ENSURE ALL STAFF CARING FOR THE PATIENT ARE AWARE IF A TOURNIQUET IS IN USE

Appendix 7 - Paediatric Lund and Browder chart

% Total Body Surface Area Burn

Be clear and accurate, and do not include erythema
(Lund and Browder)





	%	
REGION	PTL	FTL
Head		
Neck		
Ant. trunk		
Post. trunk		
Right arm		
Left arm		
Buttocks		
Genitalia		
Right leg		
Left leg		
Total burn		

AREA	Age 0	1	5	10	15	Adult
A = ½ OF HEAD	9½	8½	6½	5½	4½	3½
B = ½ OF ONE THIGH	2¾	3¼	4	4½	4½	4¾
C = ½ OF ONE LOWER LEG	2½	2½	2¾	3	3¼	3½

Appendix 8: Splinting of the face in facial trauma with uncontrollable bleeding

1. SUCTION AND IF POSSIBLE SECURE AIRWAY + TXA / TRANSFUSION PROTOCOL

2. INSERT 1 BITE BLOCK TO SIDE OF THE MOUTH

3. APPLY HARD C-SPINE COLLAR IF BLEEDING CONTROLLED

FOR CONTINUED BLEEDING FROM MAXILLA EITHER:

2 x FOLEY CATHETERS ALONG FLOOR OF THE NASAL CAVITY IN BOTH NOSTRILS
(VISUALISE TIPS PAST SOFT PALATE)

INFLATE BOTH BALLOONS (5ML) AND TRACTION FORWARDS
SECURE WITH UMBILICAL CLAMP/CLIP

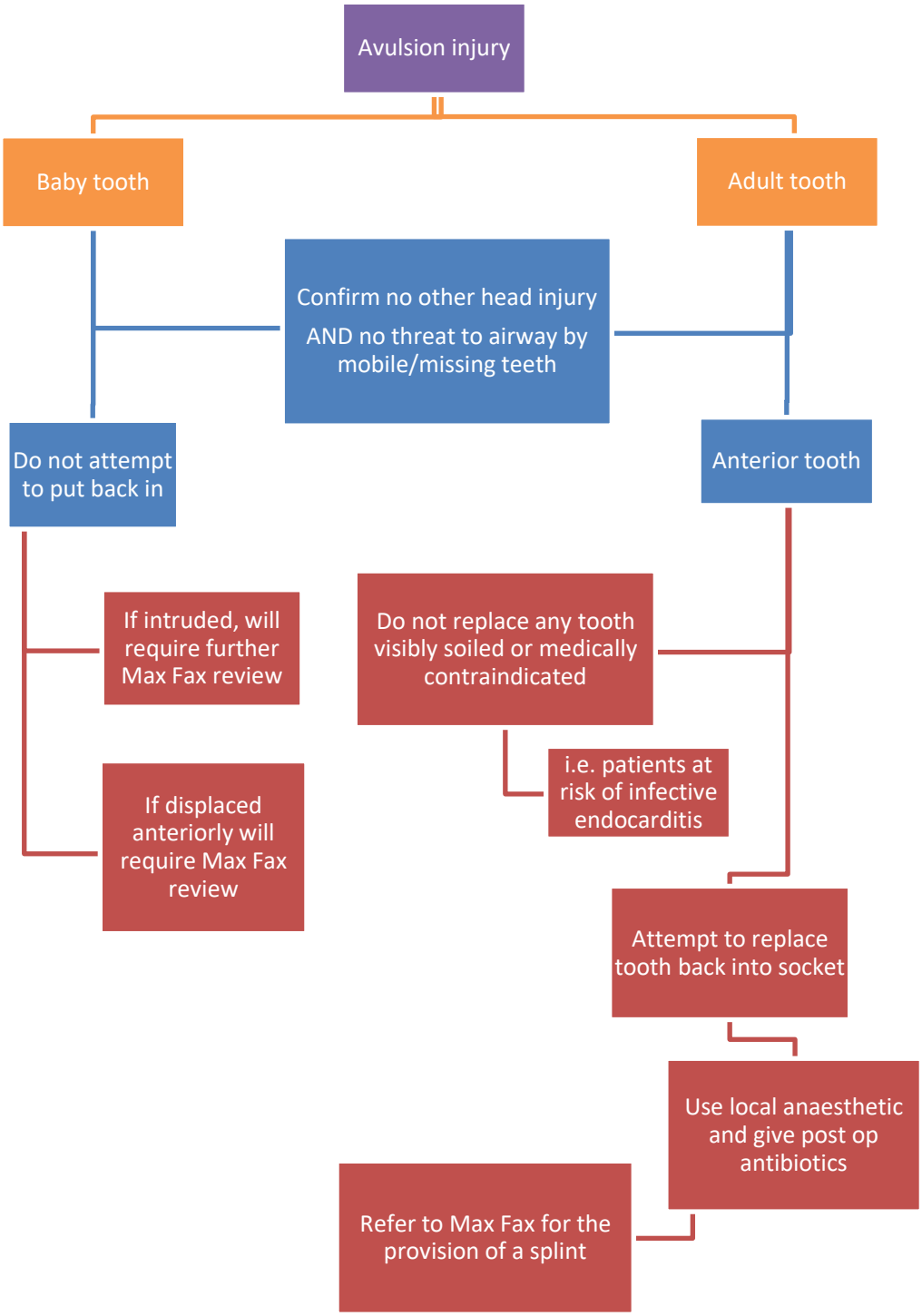
CONSIDER ANTERIOR NASAL PACKING WITH BIPP OR RAPID RHINO

2 x EPISTATS ALONG FLOOR OF THE NASAL CAVITY IN BOTH NOSTRILS

INFLATE POSTERIOR THEN ANTERIOR BALLOONS EQUALLY ON BOTH SIDES

WITH CONTINUED BLEEDING SEEK EXPERT ADVICE FROM MAXILLOFACIAL SURGERY AND CONSIDER SUPRASELECTIVE EMBOLISATION

Appendix 9 - Avulsion of tooth algorithm



Appendix 10 – Imaging reporting template

Acute primary assessment report. *BFCR(14)8 Royal College of Radiologists Paediatric Trauma Protocols*. Aug 2014.

Patient name	
Patient number	
Date of scan	

To guide initial management only. A formal report will follow. The trauma team will be notified of any major alterations to this primary assessment.

Primary assessment trauma plain films (for stable children)

Cervical spine

Normal	No CT C-spine indicated
Abnormal / clinical suspicion	CT C-spine required

Chest X-ray

Normal	No CT chest indicated Proceed to CT abdo / pelvis if needed
Abnormal / clinical suspicion	CT TAP required

CT scanning preliminary review

Airway			
ET placement	N/A	Satisfactory	Unsatisfactory
Airway obstruction		Yes	No

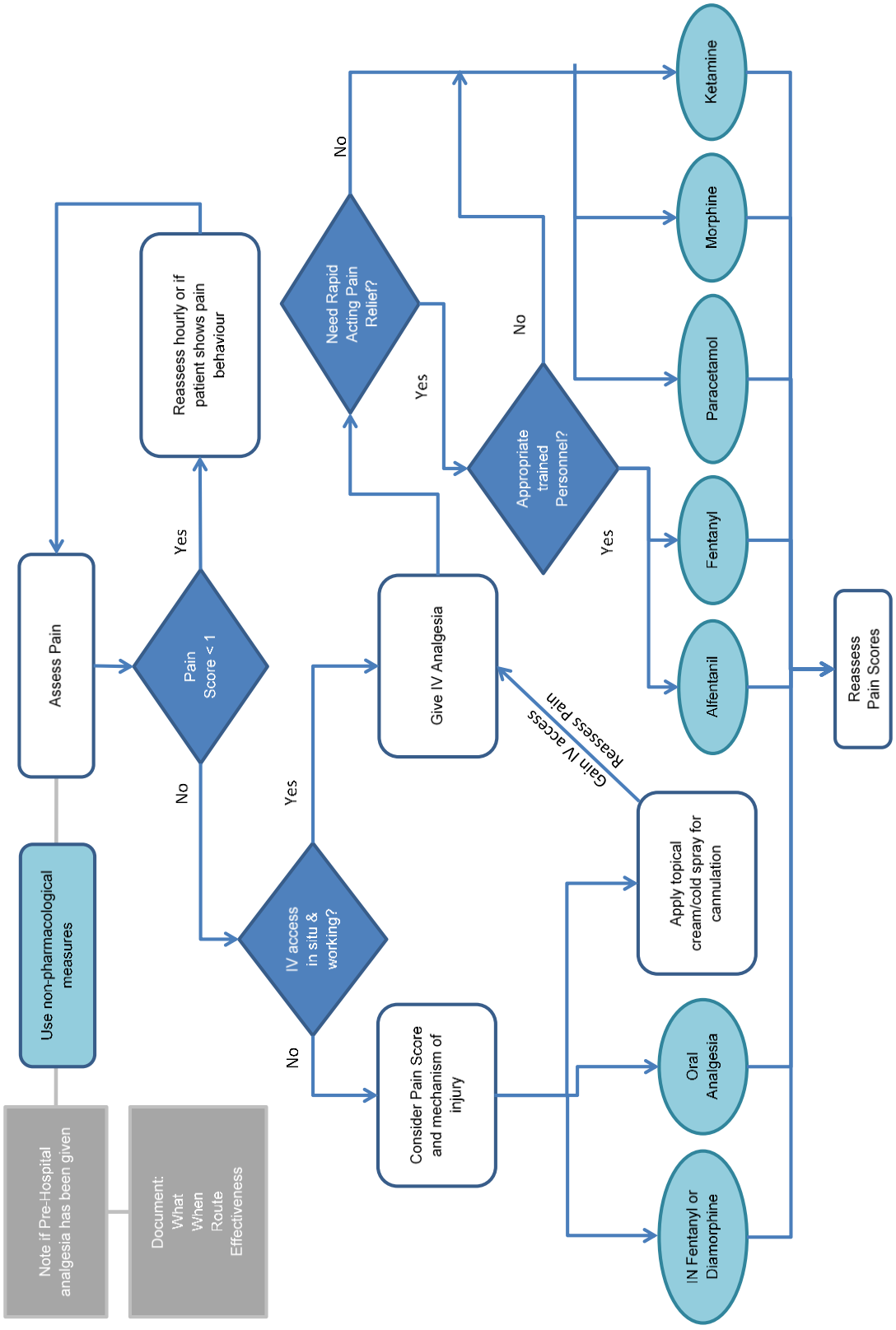
Breathing			
Contusion		Yes	No
Laceration		Yes	No
Pneumothorax		Yes	No
Chest drain placement	N/A	Satisfactory	Unsatisfactory

Circulation (bleeding)			
Pericardial effusion		Yes	No
Thoracic injury		Yes	No
Abdominal injury	Retroperitoneal	Yes	No
	Visceral	Yes	No
Pelvic injury		Yes	No
Soft tissue		Yes	No

Disability		
Intracranial bleed / oedema	Yes	No
Major spinal injury (cord compromise)	Yes	No

Comments	
Name of radiologist	
Time	

Appendix 11 - Pain management flow chart



Appendix 12 - Sources of support for families

http://www.suddendeath.org/
Sudden – supporting people after sudden death. An initiative by Brake, the road safety charity

http://www.brake.org.uk/
Support for UK residents who have been bereaved or seriously injured in a crash

https://childbereavementuk.org/
Support for families after the death of a child, including siblings

https://www.cruse.org.uk/
Cruse bereavement care – support for bereaved families

http://leedssbs.org.uk/
Leeds suicide bereavement service

https://starbereavement.org.uk/
Wakefield bereavement support for children

http://lbforum.org.uk/
Leeds bereavement forum – charity based in Leeds who will signpost individuals to the most appropriate bereavement service either locally or nationally

http://www.childfuneralcharity.org.uk/ or https://www.familyfund.org.uk/
May be able to offer financial support with funeral costs

Children's Hospices in Yorkshire & Humber
All with the exception of Bluebell Wood offer bereavement support to families not previously registered with the hospice.

https://www.martinhouse.org.uk/
Martin House, Wetherby (West, North and East Yorkshire)

https://www.forgetmenotchild.co.uk/
Forget Me Not, Huddersfield (West Yorkshire, North and Greater Manchester)

http://www.standrewshospice.com/andys
St Andrews (Andy's), Grimsby (NE Lincs, N Lincs, Hull, East Riding, Lincolnshire)

http://www.bluebellwood.org/
Bluebell Wood, Sheffield (South Yorkshire, North Derbyshire, North Nottinghamshire, North Lincolnshire Bassetlaw)