Leeds Major Trauma Centre

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Imaging in Paediatric Major Trauma

These guidelines should be read in conjunction with the following documents

Royal College of Radiologists Paediatric Trauma Protocols, Aug 2014

NICE CG 176 Head injury: Triage, assessment, investigation and early management of head injury in children, young people and adults, Jan 2014

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Background

Over the last 3 decades it has been well documented, both in the USA and UK literature that many deaths due to trauma are preventable, with unnecessary deaths being shown to correlate directly with failings and inadequacies, both in the organisation and delivery of care.

In an aim to improve trauma care and outcome across the UK, regional trauma networks (TARN) were introduced in April 2012. Each network has a designated, Major Trauma Centre (MTC): a hospital with a full range of trauma specialists, which include orthopaedics, general and vascular surgery, neurosurgery and radiology teams.

Rapid access to 'whole body' CT (scanning head-symphysis), is one of the factors that has been shown to correlate with improved survival in severely injured patient[iii]. CT allows early identification of critical injuries, and potentially life-threatening sites of hemorrhage, allowing management to be prioritized and optimized accordingly.

Whole body CT (head to symphysis) is therefore recommended as the imaging modality of first choice for any patient presenting with a history of polytrauma or severe traumatic injury.

The development of multiple Major Trauma Centre's throughout the UK, rapid access to CT, together with RCR[iii] and NICE imaging guidance for polytrauma and head trauma, has highlighted a need for specific imaging guidance for children.

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.

When LTHT gained MTC status in April 2012, there were no specific national or local paediatric trauma imaging guidelines. Since 2012 the British Society of Paediatric Radiologists together with the Royal College of Radiologists (RCR) set up a specific Trauma imaging group which published guidelines (endorsed by the College of Emergency Medicine) in August 2014[iv].

In parallel, we have developed our own LTHT joint clinico-radiological Paediatric CT Trauma Guidelines. The aims are to highlight the difference in aetiology, spectrum and surgical management of trauma in children, and the impact this has on imaging protocols and decision making. These are specific weight based CT protocols, based on the local LTHT Radiology Adult Polytrauma Protocols, local Paediatric CT audit data, US literature and local clinical experience. These guidelines accord with and supplement the RCR guidance and will be modified as NICE Major Trauma Guidance is released.

Aetiology of Paediatric Trauma

The following table shows the spectrum of the most common medical emergencies and death (traumatic vs non traumatic) in children according to age:

Neonate (birth -1month)	Infection, neglect
Infant (1 month - 1 year)	Infection, neglect, physical abuse
Toddler (1-3 years)	Poisoning, falls
Preschool (3-5 years)	RTC (pedestrian vs car) (leading cause death < 4 years) > poisoning
School Age (6-12 years)	RTC (pedestrian vs car) > falls, recreational accidents
Adolescent (13-18 years)	RTC > sport, recreational accident > drugs/ poisoning

Trauma is the leading cause of death in children > 1 year of age, with a peak in the first year of life, followed by a second peak at around 6 years. Approximately two thirds of those with severe injuries or who die as a result of their injuries are boys[v].

Death as a result of trauma is far more common in adults; with approximately three quarters of accidents occurring in men, with those under 25 years being the highest risk group. Most trauma occurs as a result of high impact road traffic collisions (RTCs).

The spectrum of trauma in children differs significantly from adults. In the majority of children injuries are mainly of extremities and to a lesser extent, head & cervical spine.

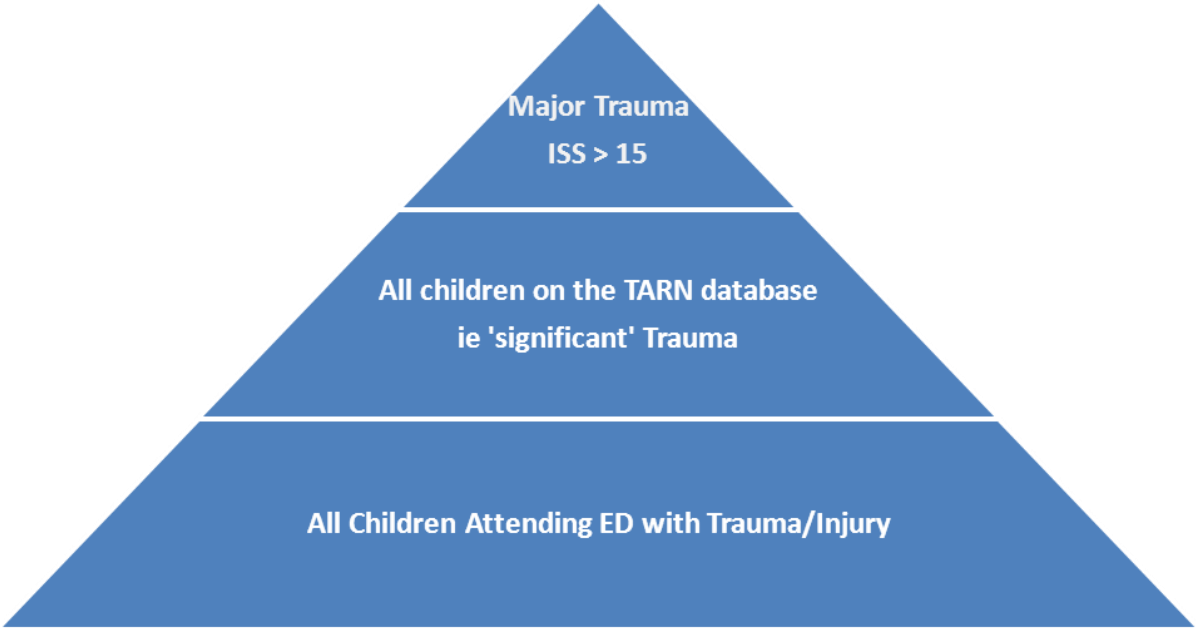


Fig 1. Severe Injury in Children. England and Wales 2012. The Trauma and Research Network (TARN)[vi]

Other than peripheral skeletal injuries, the majority of childhood trauma occurs as a result of recreational and sporting accidents. Although these accidents may seem relatively trivial, significant injury is common, ie. handle bar accidents may result in pancreatic, small bowel, and splenic lacerations.

Most deaths in children occur secondary to RTCs and falls, with the majority of severely injured children (74%), having an associated severe head injury, this being the commonest cause of death.

Most fatal RTCs occur as a result of 'knock downs' ie pedestrian vs vehicle accidents, with passenger deaths in children being relatively rare in the UK due to the routine use of car seats and seat belts, introduced in the late 1980's.

Risks from ionising radiation

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

The harmful effects of ionising radiation are widely acknowledged, however the exact detrimental effects, particularly at the low doses used in diagnostic radiography, are unknown and subject to much controversy[vii].

The effects of ionising radiation can be divided into non-stochastic (deterministic) and stochastic (random) effects.

Non-stochastic effects only occur once a threshold of exposure has been exceeded. This is the principle behind radiotherapy treatment. The severity of the effect increases as the dose increases ie cell damage or cell death. Such effects include skin erythema, cataracts, sterility and radiation sickness.

Stochastic effects follow a linear 'no-threshold' hypothesis. The risks of an effect occurring increase linearly as the dose increases, and thus there is no 'safe' low dose "threshold". The effects are cumulative and include radiation induced cancers and genetic defects.

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.

Major Trauma

The initial approach to children with major trauma is the same as in adults.

'Major Trauma' is indicated by:

- multiple serious injuries that could result in death or serious disability
- serious head injury
- polytrauma due to a RTC or *high speed* knock down
- Fall from a great height
- severe gunshot wounds

Clinical indicators of potentially significant injury include:

- **Altered mental status**, irritability, agitation, confusion ie head injury +/- blunt abdominal or spinal injury.
- **Significant mechanism** regardless of whether there are obvious injuries. In children the history may sound innocuous e.g. handle bar injury. (see below)
- **Signs that may indicate shock**: poor systemic perfusion, pallor, mottling, peripheral cyanosis- this is often a late sign in young children as they compensate better than adults.

Does the patient need to go straight to theatre?

If the child is unstable the first decision is to decide whether the child should go straight to theatre. This decision should be made by the Consultant Paediatric Surgeon and Emergency Medicine Consultant.

The following sections highlight how the different spectrum of trauma in children, and the different physiological and anatomical considerations of the growing child, affects the approach to imaging.

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…..cranial CT has been demonstrated to be associated with an increased incidence of cancer and therefore should not be used for all children [presenting with a history of] 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]

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

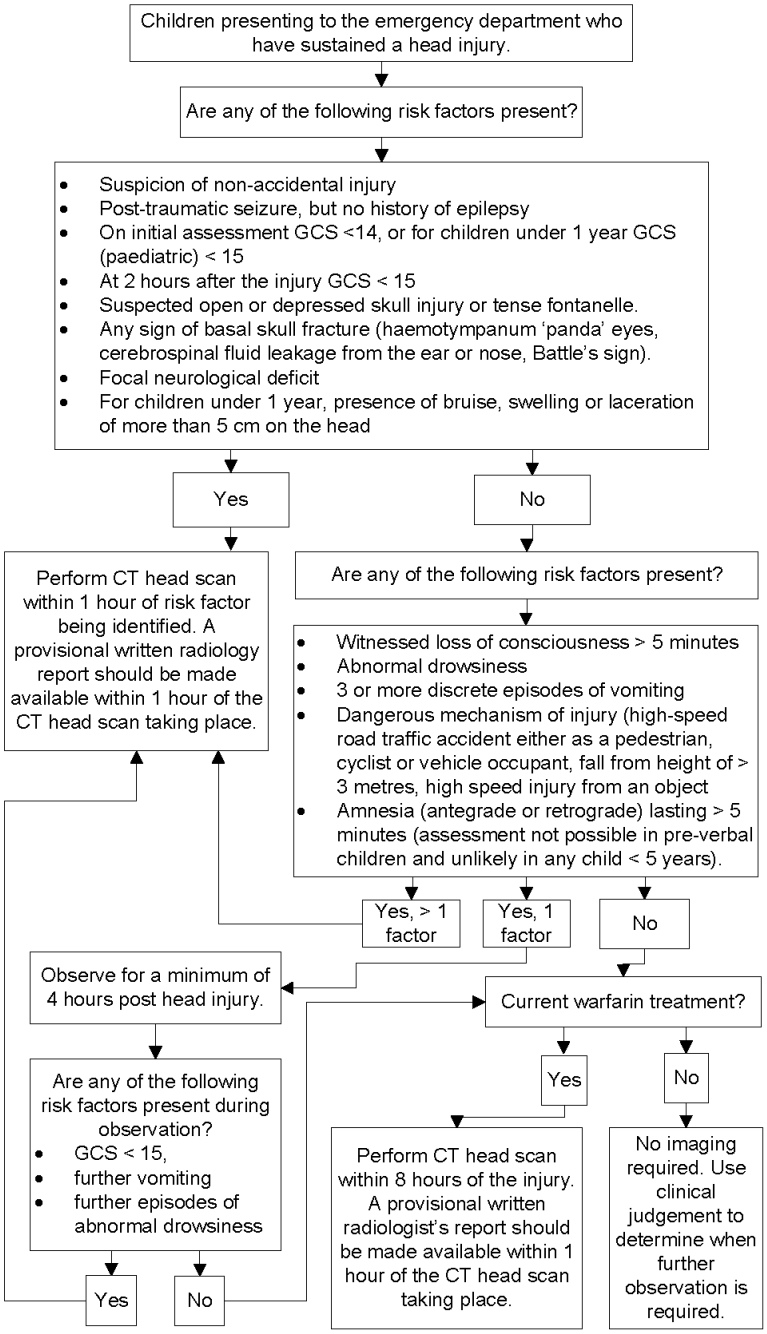


Figure 2. Selection of children for a CT head scan National Institute for Health and Care Excellence. *CG 176 Head Injury: Triage, assessment, investigation and early management of head injury in children, young people and adults.* London: NICE, 2014.

Cervical Spine Trauma[viii]

Paediatric cervical spine injury in children is uncommon, accounting for only 1–2% of pediatric trauma with motor vehicle accidents accounting for the majority under 8 years of age and sports related injuries accounting for the majority in the older child.

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 children and adults ie. infants and young children have a relatively high fulcrum, and larger head, increasing the risk of occipito-cervical injuries. Other age related differences include horizontal facets, flatter vertebral bodies, and ligamentous laxity, the latter increasing the risk of spinal cord injury, in the absence of any demonstrable bony abnormality.

Imaging

Plain films (at least 3 standard views) or CT can be the imaging modalities of choice in both adults and children with potential cervical trauma.

Imaging should however not be used in isolation and must be complementary to the clinical history, mechanism of injury, and full clinical examination.

It must also be remembered that both plain radiography and CT may be normal despite significant ligamentous injury! Whether plain films or a CT are performed should be influenced by the history, clinical examination, and level of concern.

CT vs Plain Films

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, both in adults and children, however the dose to the thyroid is reported to be 90- 200 X higher with CT, the greatest risk being in children 0–4 years old.

Effective dose C Spine 3 -4 views approximately. 0.05mSv Effective dose typical CT C Spine approximately 3.8mSv

With the introduction of MTCs and NICE guidance for Head and C Spine Trauma, the volume of CT performed in children and adolescents presenting with trauma is increasing, with the cumulative effective dose in adolescents in particular being almost 3 x those imaged at dedicated paediatric MTCs[ix].

Plain radiographs

Plain films still have a substantial role in alert, symptomatic patients.

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.

CT

In a stable child undergoing cranial CT, there should be discussion between senior multi-specialty members of the clinical team as to the most appropriate imaging of the neck.

Given the propensity of ligamentous injury and radiation risks in children, the cervical spine in children < 10 yrs, should, where possible, be 'cleared' using a combination of conventional radiography and clinical examination.

In children < 5 yrs, given the radiation burden from CT and insensitivity of CT to ligamentous injury, MRI rather than CT should be considered.

The emphasis here needs to be to think and consider the benefits and risks before imaging.

Image appropriately and keep the radiation dose as low as reasonably possible in all children, particularly those < 5 years/age.

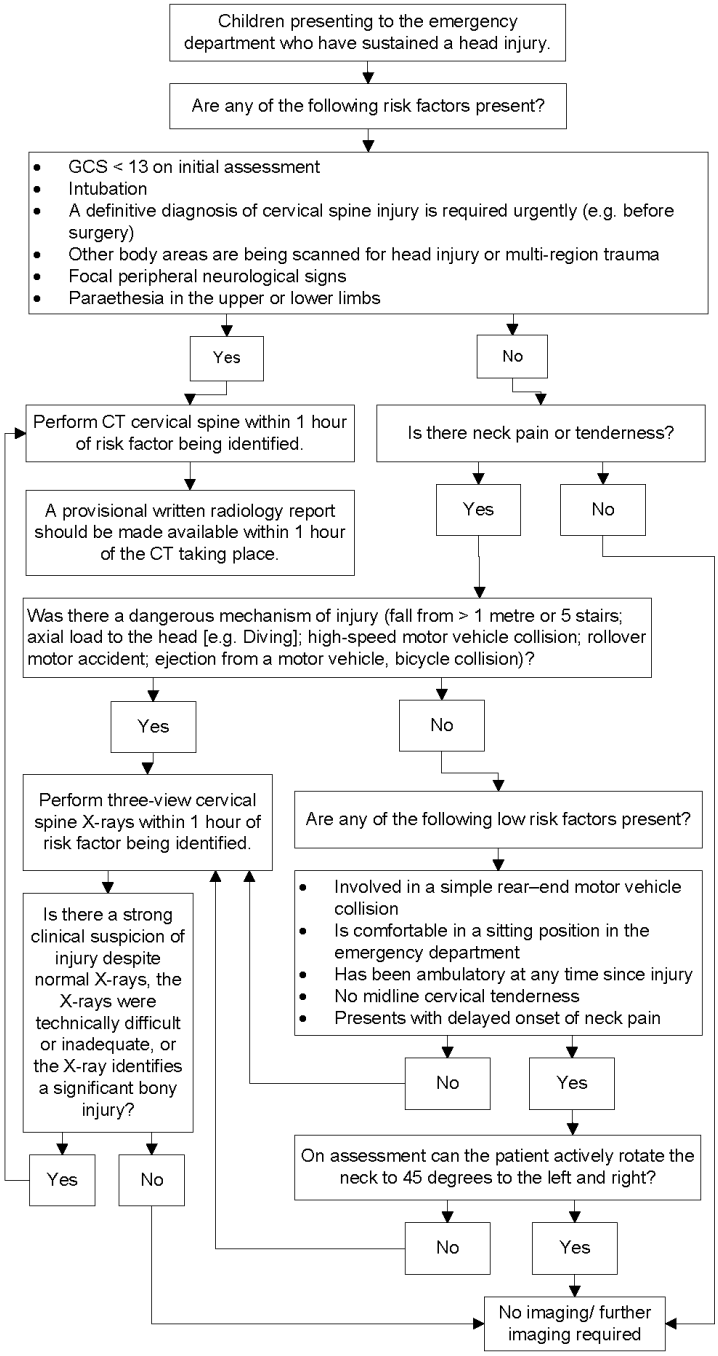


Figure 3: Selection of children for imaging of the cervical spine. National Institute for Health and Care Excellence. CG 176 Head Injury: Triage, assessment, investigation and early management of head injury in children, young people and adults. London: NICE, 2014.

Abdominal Trauma[x]

The abdomen is the 2nd most common site of injury, after head injury.

Blunt Abdominal 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.[xi] 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.

Solid organ injury, i.e. liver, splenic, renal and pancreatic lacerations, and bowel injury ie perforations and haematoma, occur more frequently in children than adults, primarily due to their relatively large organ size and high costal arch.

The following clinical signs are all associated with a higher risk of significant intra-abdominal injury; abdominal pain, guarding, bruising, abdominal distension, absent bowel sounds, vomiting, and frank haematuria. Contrast enhanced CT is the imaging modality of choice.

Absence of abdominal signs and symptoms, and asymptomatic microscopic haematuria both have a low predictive value for intra-abdominal injury. Therefore, unless there is a good history of significant blunt impact to the abdomen, CT is likely to be of limited value.

Solid organ injuries both in children and adults are usually managed conservatively (non-operatively).

If there are signs of arterial bleeding on the CT scan, the paediatric surgical and the vascular interventional radiology consultant should be contacted, to assess the patient for radiological or surgical intervention. These patients should be closely clinically monitored.

There have been numerous studies, looking at laparotomy rates, grade of injuries and outcome in children with solid organ injury. All studies have shown a low operative intervention rate. In one study of 122 children with isolated hepatic or splenic injury, over a 10-year period, only 3% of hepatic and 2% of splenic injuries required laparotomy[xii] and in a more recent multicenter study of 316 children with isolated grade I–IV hepatic or splenic injury only 1% required laparotomy

Penetrating Trauma

Penetrating trauma, i.e. stabbings remain relatively rare in the UK, with the exception of inner city areas, particularly London, where they are increasing in frequency, primarily as a consequence of gang violence. In the context of penetrating trauma CT is the imaging modality of choice, unless there is a need for immediate operative intervention.

Radiological signs of intra-abdominal injury

Imaging findings are often subtle, and may be missed unless considered!

Bowel trauma in particular can be difficult to diagnose. The salient features on CT are bubbles of extra-luminal gas +/- free fluid. Other signs may include focal bowel wall thickening, bowel wall disruption, leakage of bowel contents e.g. faeces. The presence of fluid with no obvious aetiology should raise concerns for bowel trauma. Subtle mesenteric triangles of fluid may be the only clue!

Solid organ injuries should be described and assessed for the presence of laceration, hematoma, and vascular injury.

Liver Trauma The liver is the most common organ injured following blunt abdominal trauma. Lacerations more commonly occur in the right lobe and are often associated with hematomas.

Vascular hepatic injury is rare in children. De-vascularized segments appear as low-attenuation areas on CT that may be wedged shaped and may fail to show contrast enhancement

The liver is surrounded by a thin capsule which is covered by peritoneal reflection. The presence of haemoperitoneum, indicates the laceration has involved the liver surface and breached the capsule. Hepatic injury is associated with haemoperitoneum in approximately two thirds of cases. If the laceration extends only to the bare area of the liver, this may lead to associated *retroperitoneal hemorrhage*, with blood often surrounding the right adrenal gland or extending into the anterior para-renal space.

There are several grading systems for liver lacerations. Grading however has not been shown to correlate with either a need for surgical intervention or outcome in children and therefore these injuries should be described rather than graded in children

Pancreatic Trauma Pancreatic fractures are often subtle, particularly initially. Pancreatic injury should be suspected if you see fluid collections anterior to the pancreas within the lesser sac.

Pancreatic injury should also be considered if there are injuries to adjacent organs i.e. the left kidney & adrenal, duodenum, and left lobe of the liver.

Pancreatic fluid often displays significantly lower attenuation than fluid or haemoperitoneum elsewhere. Carefully follow the anterior sweep of pancreatic contour and try and identify contour change/disruption.

If there is pancreatic head injury, the gall bladder pedicle, and CBD must be carefully assessed for injury.

Pelvic Trauma

Injuries to the bony pelvis are usually associated with major trauma i.e. high speed RTA's, knockdowns and falls from great heights. Even in the context of significant trauma to other body parts, pelvic fractures are rare in children.

If the child is well and asymptomatic despite a 'mechanism' of high impact trauma, no imaging may be necessary.

If the child is well and stable but there are concerns a pelvic X ray +/- frog leg lateral hips should be performed initially.

In the context of a history of high impact trauma, + clinical concern, CT is the imaging modality of choice. This should include the whole abdomen and pelvis and should be performed with intravenous contrast medium.

Sacral injuries can be very subtle, even on CT, yet are potentially very important as are acetabular fractures. Where there are suspected pelvic +/- acetabular injuries, images should be reconstructed with coronal +/- sagittal reformats.

Chest Trauma

Major chest trauma resulting in serious life threatening injures i.e. cardio-vascular injury, is a marker of severe multi-system injury and remains the 2nd most common cause of death after head trauma, in adults.

Over 90% of chest trauma occurs secondary to a blunt impact, usually following high-energy motor vehicle accidents or pedestrian knock downs.

Major chest 'cardiovascular' trauma in children is rare in the UK, due to the routine use of seat belts in vehicles, together with increased compliance of a child's chest wall, compared to adults.

The CXR is the primary imaging modality in a stable well child following blunt chest or thoraco-abdominal trauma. Indications for CT as the primary imaging modality include:

i. Penetrating trauma to chest or abdominal organs adjacent to diaphragm
ii. High impact injury to chest/upper abdomen
iii. Clinical concern
iv. Abnormal mediastinum on CXR

External signs of injury may be absent, or very minimal in children with significant chest trauma

The presence of rib fractures indicates a severe impact. Rib fractures are often invisible or very subtle on a CXR following acute injury. Their absence therefore does not exclude significant intra-thoracic injury.

Pulmonary contusions, pneumothorax, and haemothoraces are common findings, even following low impact chest/thoraco-abdominal trauma. These injuries are usually tolerated extremely well. Unless the child is intubated and ventilated, or the CT is performed as part of a polytrauma series, these findings alone are not an indication alone for chest CT[xiii].

Requesting a Trauma CT

During office hours (Monday - Friday 0900-1700) contact:

1. Paediatric Acute Reporting 25165 **or**
2. Paediatric PA 22336 **or**
3. The **On Call Consultant Paediatric Radiologist** on their mobile phone (via switchboard)

Out of hours contact:

The On Call Radiology Registrar via switchboard or walk round to CT.

Contact the CT radiographers on x 23617 to alert them of the CT and arrange timing and transfer of the child.

If a full Polytrauma CT is felt clinically appropriate complete the 'CT Polytrauma' request card or via ordercomms.

For a more limited CT complete an ordinary Radiology CT Request - via ordercomms.

Ensure the Radiologist is aware of any plain films or CT imaging performed prior to the CT or elsewhere. This should be reported along with any additional imaging performed.

Transfer to CT

- Prior to transfer ensure intravenous access. This should be via the largest cannula possible ideally placed in the right ante-cubital fossa.
- Clamp the urinary catheter if present.
- Decompress the stomach with an NG tube if possible, but do not delay CT for this.
- For a full polytrauma CT oral contrast is **NOT** required
- Full monitoring must be used (HR, NIBP, Sats & CO_2 if intubated)
- Monitoring devices and metallic leads should be moved from the scanning plane because they will cause streak artifacts.
- Transfer should be as smooth and fast as possible. Aim to use either the trauma transfer mattress (when available) or leave the patient on the scoop stretcher. The scan can be performed on the scoop stretcher but ensure that there is as much distance as possible between the top of the patient's head and the metal clip at the top of the stretcher.
- If the patient cannot be transferred on a stretcher or transfer mattress then 4 staff must accompany the patient to allow safe log-rolling and sliding.
- Phone CT on x23617 when leaving A&E to ensure they are ready.
- The most senior doctor (plus anaesthetist if necessary) and one nurse **MUST** stay in the control room whilst the patient is being scanned. **ALL** other non CT personnel must wait outside the CT control room to allow the radiographer to perform the scan, and the radiologist to issue an initial report without interruption/distraction.

Paediatric Trauma CT Protocols

1. Blunt CT imaging will either be targeted or a full 'polytrauma' CT.
2. Polytrauma CT will be either
    a. Stable polytrauma OR
    b. Unstable polytrauma
3. Penetrating trauma CT is considered separately

1. Targeted CT

The majority of Paediatric Trauma is not Polytrauma!

- A full polytrauma series or CT chest abdomen and pelvis should not be an automatic request
- A CT head +/- C spine + CXR should be considered if the child is stable.
    - A history of head injury alone
    - No clinical indicators of torso or abdomino-pelvic trauma,.
- In clear blunt trauma to the abdomen i.e. handlebar injuries, a CT of the abdomen and pelvis together with a plain CXR is usually sufficient.
- In stable children with a history of blunt chest or thoraco-abdominal trauma - especially young children, the need for chest CT in preference to a CXR is controversial,
    - Lung contusions and pneumothoraces are common but significant vascular injury is very rare.
    - A CXR in the majority will be sufficient.

The need for chest CT should be decided by the ED Consultant or Paediatric Surgical Team and should depend upon the mode of injury, the speed of impact, and clinical assessment of the child.

Targeted Trauma CT: Stable Protocol

Blunt abdominal trauma may occur in isolation, or as a result of a 'low impact' RTA, pedestrian knock downs, or falls

The need for and extent of imaging should be influenced by the clinical history and examination.

CT is well recognized to be more sensitive and specific than USS in the detection of haemoperitoneum, bowel injury and perforation, and the diagnosis and grading of solid organ injuries. However the extent of the CT and area of coverage should be tailored accordingly.

CT Technique Focus to the area of clinical concern

Chest: CT Technique:

- Arterial phase CT chest

Abdomen and pelvis: CT Technique

- No oral contrast
- IV Contrast: see Bastion Protocol
- Scanning parameters: as per GE Paediatric weight based CT protocols
- Spine 1mm axial and 2mm sagittal • coronal 3mm bony pelvis

2. Polytrauma CT

- A 'Polytrauma CT' includes imaging of the head, neck, chest, abdomen and pelvis.

This is a high dose procedure with mean cumulative dose estimates in children of 20.8mSv (equivalent to approximately 2100 CXR's). The referrer therefore must be able to justify this request.

A full Polytrauma CT series is the imaging investigation of choice in the context of:

- 'True Polytrauma' i.e. significant injuries to 2 or more body regions
- Multi-system injury.

- Any concern for a spinal injury (uncommon unless high speed impact).

A full polytrauma CT should be **considered** in any child who has suffered injuries as a result of a significant mechanism of injury:

- High speed road traffic accidents (ie > 60mph)
- High speed RTA where there has been a death of another occupant of the same vehicle.
- Pedestrian knockdowns.
    - **Pedestrian knockdown per se** are not an indication for a whole body Polytrauma CT and a focussed CT may be more appropriate.
    - The decision should be guided by clinical concern and following clinical assessment.
- Falls from a 'height '
    - Falls from height greater than their own are **very common** in children. Unlike adults these falls are ***not*** necessarily associated with significant injury. This history should therefore not be an automatic indicator for a Polytrauma CT in a child.
    - Focussed CT may be more appropriate together with clinical assessment. The child should be clinically assessed and the extent of imaging should be decided on a patient- patient basis.

The decision for a full polytrauma series CT should not be an automatic reflex request. After clinical assessment, the decision and extent of imaging should be made by the Consultant in Emergency Medicine.

Any disagreements need to be resolved by Consultant-Consultant discussion

Polytrauma CT

If a full polytrauma scan is indicated it should not be delayed for plain films.

As for the adult LTHT Polytrauma Protocols the type of Polytrauma CT depends on the haemodynamic status of the patient:

- The Standard Polytrauma Protocol
    - Indicated for a child who is haemodynamically and clinically stable

- The Haemodynamically Unstable Polytrauma Protocol
    - For the child who is clinically unstable.

2a Polytrauma CT: Standard Protocol

Areas to be Scanned:

- Head
  - Non-contrast CT head
- Cervical Spine
  - C spine 1mm axial 2mm coronal & sagittal recons
  - Imaging of the head and cervical spine is covered by NICE clinical guideline 56
- Chest
  - Axial Coronal and Sagittal reformats
- Abdomen and Pelvis
  - Axial and coronal reformats to symphysis pubis.
- Consider limb in complex limb injuries
- CT Technique
  - No oral contrast
  - Scanning parameters: as per GE Paediatric weight based CT protocols
- Spine 1mm axial and 2mm sagittal
- coronal 3mm bony pelvis
- IV Contrast
  - See Bastion protocol

The Bastion Protocol

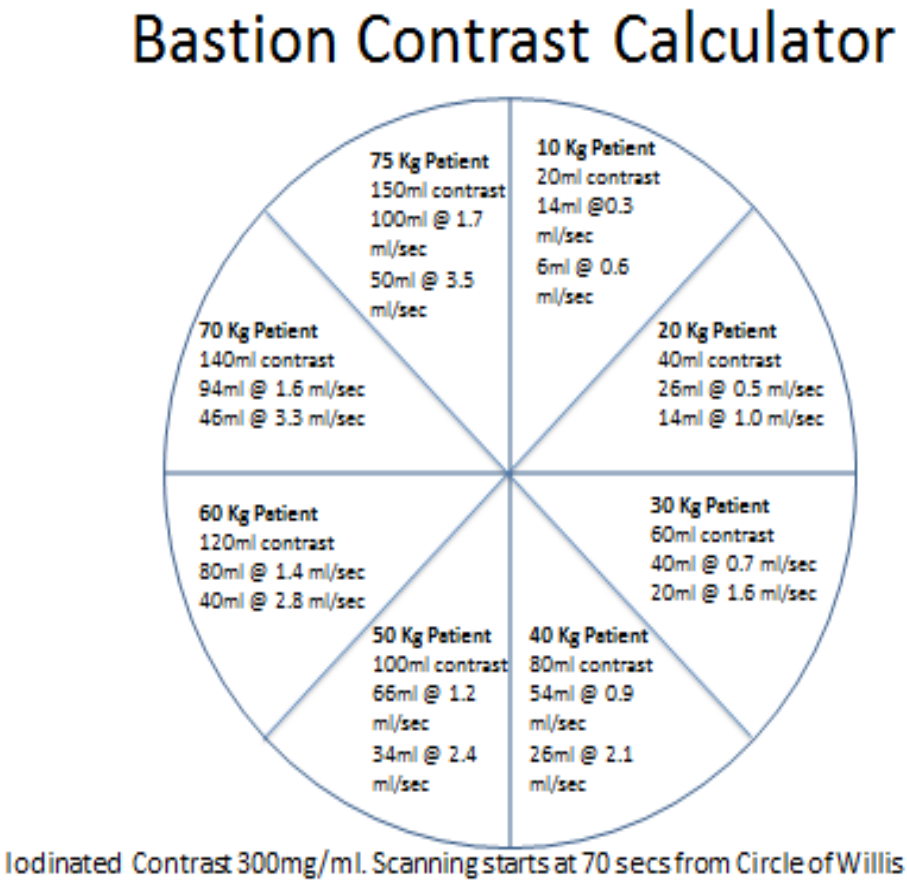
This method of contrast administration is routinely used in Birmingham Children's with great success, and is being increasingly used at other 'Children's Trauma centres' throughout the UK.

We have been using this technique at the LGI in children with 'stable' non penetrating trauma since March 2013, with good quality diagnostic CT imaging.

There is however a potential problem with this technique, with the result of a superimposed 'arterial and venous phase' CT scan. This may cause potential difficulties in differentiating arterial from venous bleeding.

For the present our recommendations in Leeds are to use the Bastion Protocol in children with Stable BLUNT abdominal trauma or STABLE Polytrauma.

If there is a high risk for active bleeding or there is penetrating trauma a dual phase (arterial and venous phase) CT should be performed for the present time until this technique can be further evaluated.



The advantages are its simplicity, i.e. a timed start **at 70 secs.** There is no bolus tracking and no saline chasing i.e. starts with a single button press. The wheel calculator has extrapolated the doses down for children.

The basic dose regimen is 2/3 slow(x) and 1/3 quick at a rate of y = 2x, with the total contrast injection taking approx. 70 s

2b Polytrauma CT: Unstable Protocol

- This protocol is aimed at a specific subset of patients where CT forms part of the ATLS/APLS primary survey with the focus of the study aimed at detecting acute life threatening injuries.
- This protocol should be used where there is clinical evidence of bleeding, or a high likelihood of vascular trauma.
- If major visceral injury and active bleeding is suspected
- Presence of likely pelvic injuries. These require a large force and are commonly associated with extensive bleeding.

Area to be scanned

- Head, neck, chest, abdomen, pelvis (C6- groins)
- Arterial phase, portal venous +/- delayed.
- Consider extending to knees if severe pelvis and lower limb trauma

Technique

- Oral contrast is not required. *This may hide bleeding sites.*
- Use a **R Antecubital Vein** if possible
- **Arterial phase -** start scanning at 25 seconds.
- IV contrast: Niopam 300 2ml/kg 2-3mls /sec depending on cannula size or children < 55kg or 150ml total volume at 3-4ml/s in adolescents > 55kg.
- **Portal venous phase** -the abdomen and pelvis should be rescanned in PV phase (not before 60-65 seconds).
- **Delayed phase**. Abdomen and pelvis 60 seconds post commencement portal venous phase – only if there is suspicion for bleeding on the enhanced series
- Review axial sagittal and coronal reformats.
- The aim is to look for foci of active bleeding and determine whether this is arterial or venous in origin.
- Active arterial bleeding in children is often self-limiting. In adults, it is not and either embolization or surgical intervention is usually required.
- Where there is concern for active bleeding the case must be discussed immediately with the Paediatric Surgeons and with the Vascular interventionist on call and a joint decision, Consultant – Consultant should be made re need for vascular intervention.

- Where the findings are equivocal (and patient stable) the on call Paediatric Radiologist should be contacted.
- The initial images should be reviewed on the scanner console.
- If there is any uncertainty/suspicion for active bleeding delayed imaging should be performed through the area of concern. If there is any doubt, a delayed CT should be performed.

Salient CT signs of active bleeding within a solid organ:
The spleen is the most frequently involved organ. Focal areas of high density ie compared to the density of an adjacent non-injured vessels. If extravasation is suspected, the patient should be rescanned through the organ- arterial phase, - active contrast extravasation will maintain or increase its density with time whereas a traumatic AV fistulae will wash-out in a similar manner to adjacent vessels.

If renal trauma is suspected, a triple phase, arterial, portal venous and 5-10 minute delayed series through the kidney and upper ureter should be performed.

If any doubt, discuss directly with the Vascular Radiologist.

3. CT in penetrating paediatric trauma

Does the patient need to go straight to theatre?

If the child is unstable the first decision is whether or not the child should go straight to theatre. This decision should be made by the Paediatric Surgical and Emergency Medicine Consultants.

What type of CT should be performed in penetrating trauma?

Stable patients with stab wounds to the torso should undergo CT. The CT coverage should be tailored according to the site of injury. The chest and abdomen must be covered in penetrating injury in the location of the diaphragm.

When should rectal contrast be used in penetrating trauma?

As in adult penetrating trauma, the use of rectal contrast is not "routine practice" in children. In stable children with penetrating trauma a contrast enhanced dual phase **(unstable CT protocol)** should be performed initially.

Repeat CT with oral or rectal contrast following the initial diagnostic study may subsequently be required to help detect bowel injury. In most cases, rectal contrast is not necessary. When required, in young children this may require a GA or sedation. This should only be performed after discussion with the paediatric surgeons.

Rectal Contrast Technique (Adults):
1000 mls (the volume will be less in children) 2% iodinated contrast delivered via a bag under gravity via a ballooned Foley catheter.
1000ml (less in children) 2% oral contrast over 30-60 mins

CT cystography

CT cystography will almost certainly be needed in severe pelvic trauma.

Delayed imaging through bladder is not advisable. This technique is usually suboptimal, optimal bladder distension is rarely achieved ie need to wait at least 12 minutes to get adequate contrast excretion. This delays review of other imaging and may be detrimental to patient treatment.

CT cystography requires close liaison with the Paediatric surgeons, Paediatric urologists and Paediatric Radiologist. It is likely that this would require general anaesthesia in children and thus may need to be performed electively after the initial CT.

A urinary catheter should be inserted by an experienced paediatric surgeon, urologist or A&E clinician. If there is a possible urethral injury, if the child is in urinary retention or it is deemed unsafe to catheterise, a supra-pubic catheter should be inserted by the Paediatric surgical team.

If there is any blood at the meatus prior to catheterisation, or any history of haematuria since the accident, a retrograde urethrogram should be performed prior to catheterisation. This needs discussion with the Paediatric Surgeons in conjunction with the Paediatric Radiologists.

Technique CT Cystography
200-300mls 4% contrast is introduced via urinary or suprapubic catheter via a bladder syringe. Repeat the CT through the pelvis. Extravasated bladder contrast is easily recognised.

Reporting

- An immediate tick box report (see trauma chart for format) should be completed prior to the patient leaving the CT room.
- The full provisional report should be available on the results server within 1 hour.
- Important clinical findings should be relayed in person or by phone to the lead clinician identified at the time of CT request or by contacting ED Consultant on x28927 or ED Nurse in Charge on 28908.
- Any difficulties in image interpretation must be discussed with the Paediatric Radiology Consultant on call.
- CT signs of active bleeding should be discussed directly with the Paediatric Surgeons and the Consultant Interventional Radiologist on call, The Consultant Paediatric Radiologist on call should also be informed.
- A full confirmed report should be completed within 24 hours.

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