

Severn & Peninsula Major Trauma Networks

South West Paediatric Major Trauma Network & Major Trauma Centre

Radiology Policy

December 2018, V1

Authors: P. Davis, J. Fryer, G. Haythornthwaite, T. Mendes da Costa, M. Chopra

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AUTHOR/FURTHER INFORMATION	Peter Davis, South West Paediatric Major Trauma Network Lead Giles Haythornthwaite, Jenni Fryer – Paediatric Major Trauma Centre.
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1. Introduction and purpose of the policy

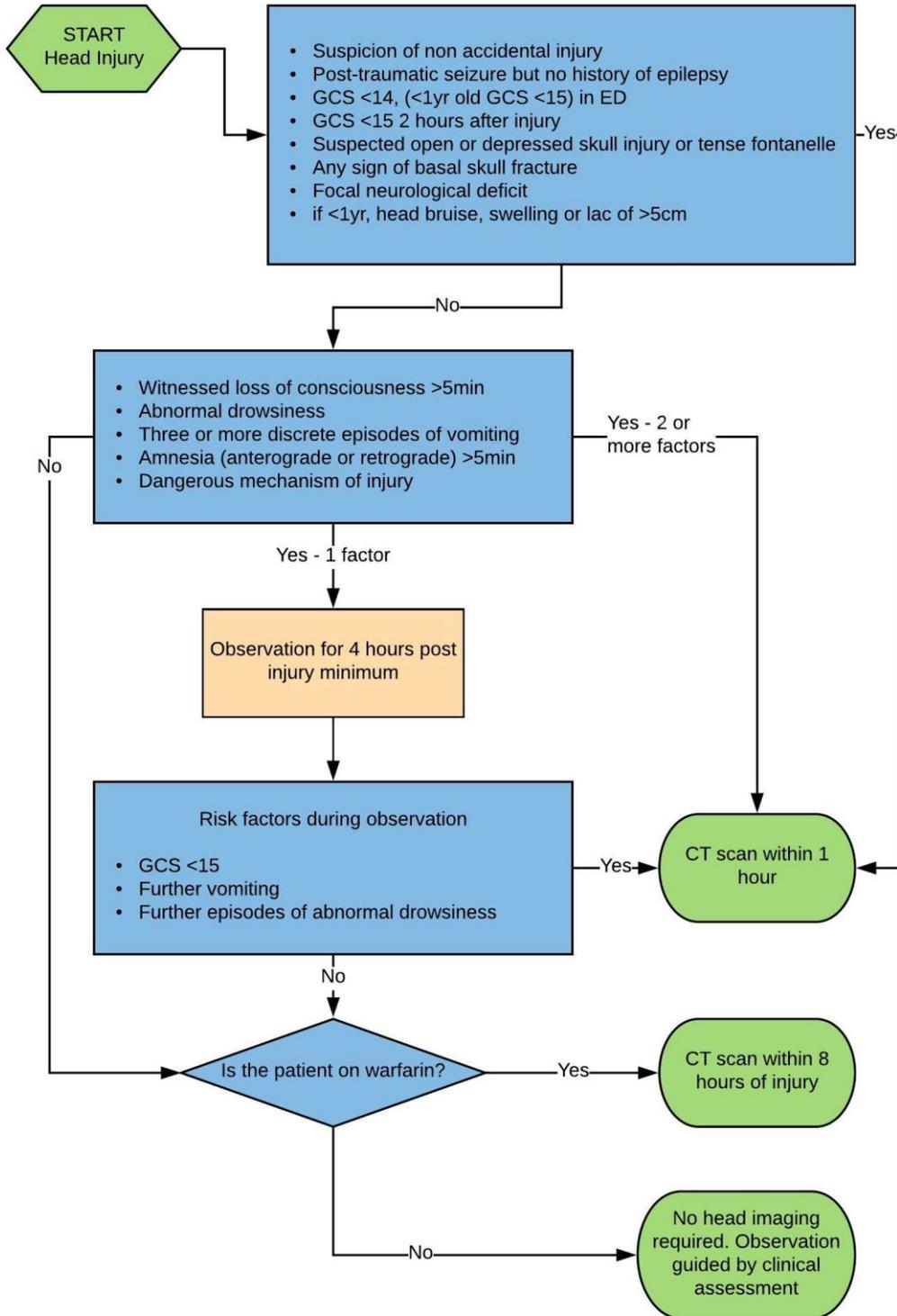
- 1.1 This policy provides direction and guidance for key individuals and organisations to improve the radiological investigation for paediatric major trauma patients.
- 1.2 The policy has been formally agreed and accepted by the Severn and Peninsula Trauma Networks (the Networks), which together constitute the South West Paediatric Major Trauma Network. It relates to paediatric patients with major trauma within these networks.
- 1.3 It is the joint responsibility of the Paediatric Major Trauma Centre (PMTC) at Bristol Royal Hospital for Children (BRHC) and the Networks to ensure that that this policy is followed and that all investigations are conducted appropriately.
- 1.4 This policy applies to the Trauma Units (TU) and the PMTC. It is the responsibility of the PMTC and TUs within the Networks to ensure that this policy is adhered to by all personnel.
- 1.5 This policy applies, 24 hours a day, 365 days a year.
- 1.6 Major Trauma patients are defined using the Trauma Audit and Research Network (TARN) inclusion criteria (see Appendix 1).
- 1.7 With regards to radiology, the aim of the Major Trauma networks is to ensure that all Paediatric Major Trauma patients receive appropriate investigation to guide management and treatment. Those children who present first to a Trauma Unit (TU) with Major Trauma, should undergo radiological investigations in line with this policy.
- 1.8 A child is defined as a person under, and not including, their 16th birthday.
- 1.9 As per the Royal College of Radiologists Paediatric Trauma Protocols (1), it is important to recognise the different physiological and anatomical considerations of the growing child and to highlight the difference approach to imaging needed.
- 1.10 The decision-making in imaging injured paediatric patients should always be underpinned by clinical discussions at senior level between radiologists, emergency physicians and other relevant subspecialties.
- 1.11 All imaging should be appropriate to the child's age and clinical condition and should be reported by a suitably trained radiologist.
- 1.12 Exposure to ionising radiation should always be kept to a minimum and the "as low as reasonably achievable" (ALARA) principles should be adhered to. The "routine" use of adult protocols is unacceptable.

*This policy will be monitored jointly by the PMTC and TU clinical and managerial leads, and the Severn and Peninsula Major Trauma Network boards.
A formal review will be undertaken biennially and amendments will be made as necessary.*

2. Imaging of the head in the injured child

- 2.1 CT is the primary investigation for cranial imaging in the child who has suffered head trauma. It displays high sensitivity and specificity for the identification of traumatic brain injury.
- 2.2 The dose of ionising radiation for a cranial CT scan is associated with an increased incidence of cancer, so should not be used for all children presenting with a head injury. The indications for a cranial CT are shown in the flow diagram below (Fig. 1)
- 2.3 All children with head injuries should be assessed promptly by an appropriately trained professional, and immediately if there is a reduced level of consciousness. Adequate resuscitation, clinical examination and administration of analgesia should take place in the process of deciding to perform a cranial CT scan (2).
- 2.4 Isolated head injuries are common in childhood and fulfilling the criteria for a cranial CT is not an indication on its own for a CT scan of the cervical spine or any other body part (see sections 3, 5, 6 & 8).
- 2.5 A cranial CT should be performed within 1 hour of presentation (within 30 minutes at PMTC) (3) and before administration of intravenous contrast.
- 2.6 MRI of the head should be performed at day 2-5 after presentation for all children when cranial CT scanning has demonstrated suspected non-accidental intracranial haemorrhage and/or parenchymal brain injury and/or skull fracture (4).
- 2.7 MRI of the head should be performed at day 2-5 after presentation for children in whom there are on-going abnormal neurological symptoms or signs, secondary to suspected non-accidental head injury, irrespective of an apparently normal initial cranial CT scan.
- 2.8 Any child who has an MRI of the head in the context of suspected non-accidental injury should also have an MRI of the whole spine at the same time (4).
- 2.9 In children with suspected non-accidental injury, cranial CT and MRI scans should be reported by a radiologist with appropriate expertise in paediatric neuro-radiological imaging. If such expertise is not available in an acute situation, the imaging should be reviewed at the earliest opportunity by a radiologist with the specified expertise (4).

Fig. 1 Cranial CT scan decision flow diagram

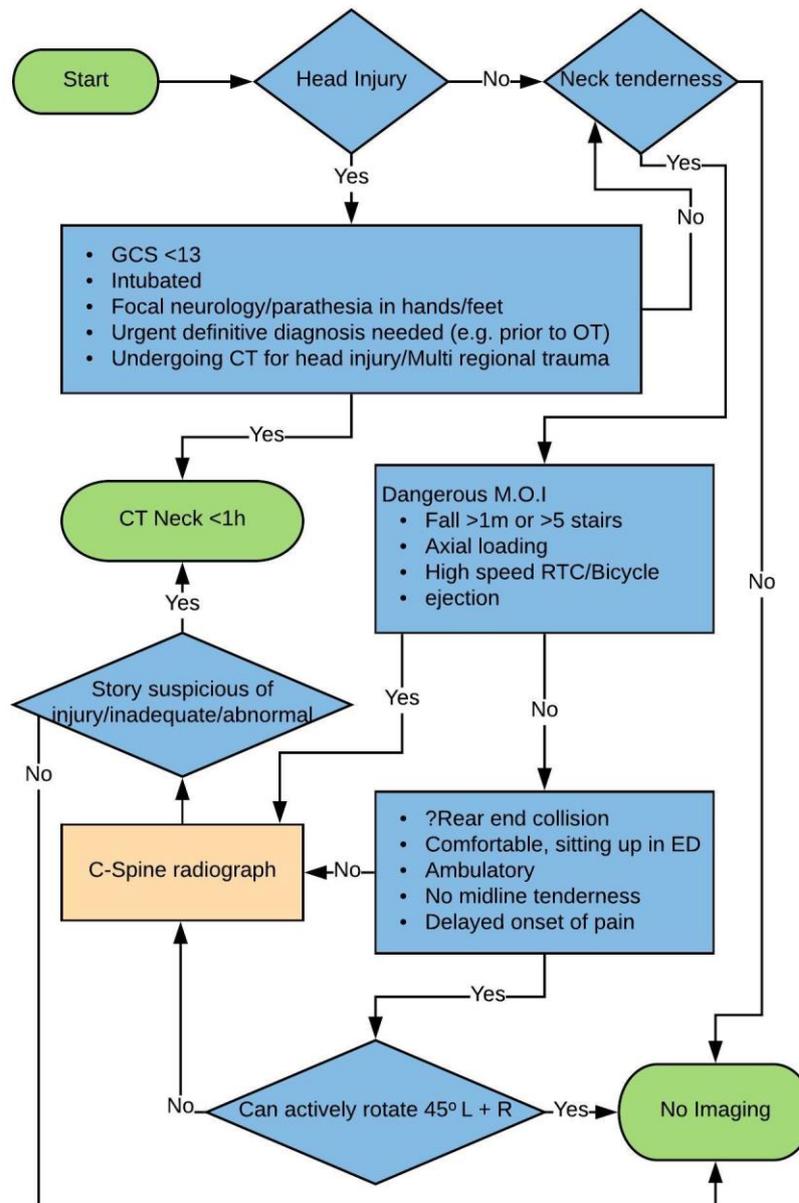


3. Imaging of the cervical spine in the injured child

- 3.1 Paediatric cervical spine injury is uncommon. Appropriate clinical evaluation, including a full history and examination, must be undertaken wherever possible, before imaging is performed, as it is an anatomical area that is relatively radiosensitive. Imaging should not be used in isolation as a diagnostic measure.
- 3.2 Initial imaging of the cervical spine may be plain radiographs or CT depending on the clinical situation.
- 3.3 Where plain X-rays are indicated, an adequate cervical spine series depends on:
 - 3.3.1 Lateral cervical spine X-ray to include base of skull and C7/T1 junction;
 - 3.3.2 Anteroposterior cervical spine X-ray to include C2 to T1;
 - 3.3.3 An adequate peg view if possible (may be difficult in young children).
- 3.4 In a stable child undergoing cranial CT scan, discussions between a senior radiologist and senior clinician as to the most appropriate imaging of the neck is indicated (2) (see flow diagram in Fig. 2)
- 3.5 If cervical spine injury is suspected, MRI allows improved evaluation of the supporting soft tissues and direct visualization of the ligamentous structures when evaluating a child for injury. The cervical cord is optimally evaluated using MRI and may be prognostic by showing haemorrhage within the cord.
- 3.6 Facet joints of the cervical spine are well visualized on MRI and may be distended with fluid with distraction and/or flexion type injuries, indicating a capsular injury.
- 3.7 The presence of epidural haemorrhage and post-traumatic disk protrusion can be easily evaluated using MRI. Epidural haemorrhage along the clivus is indicative of occipital cervical ligamentous injury, and may be initially seen on head or cervical spine CT studies.
- 3.8 Bony injuries of the cervical spine may be more easily visualized with MRI, with compression injuries showing increased T2 signal with little or no vertebral body height loss and injury involving the dens synchondrosis by showing oedema within the adjacent bone



Fig. 2 Cervical spine imaging decision flow diagram



4. Imaging of the spine in the injured child

- 4.1 Potential spinal injuries should be judged on a case-by-case basis with appropriate discussion with a radiologist where the clinical condition allows.
- 4.2 Plain X-rays of the injured region, as based on clinical assessment, will generally be the primary investigation.
- 4.3 Targeted CT of an area may be necessary for further assessment.
- 4.4 If there is a high suspicion of a thoracic spine injury, plain X-rays and MRI are recommended.
- 4.5 CT of the lumbar spine is included in CT of the abdomen and pelvis. If there is evidence of a duodenal or pancreatic injury secondary as part of the Seat Belt Syndrome, the thoracolumbar junction should be reviewed for evidence of a Chance fracture of the spine (5).
- 4.6 Where there are definitive neurological signs, MRI should be the primary imaging modality.
- 4.7 As noted in 2.8, an MRI of the whole spine should be performed at the same time, whenever a child has an MRI of the head in the context of suspected non-accidental injury (4).

5. Imaging of the chest in the injured child

- 5.1** The primary investigation for blunt chest trauma is the chest X-ray. This will detect pneumothorax, haemothorax, rib fractures, gross mediastinal abnormalities, diaphragmatic injuries and rib fractures.
- 5.2** Penetrating chest trauma is an indication for contrast-enhanced chest CT due to the incidence of occult vascular injury.
- 5.3** Further imaging in blunt chest trauma should be dictated by the nature of the trauma, the clinical findings of the child and the initial radiological findings on chest X-ray (CXR).
- 5.4** CT chest can be avoided if the chest X-ray is normal, and the child is conscious and clinically stable, as it is unlikely to lead to a change in management.
- 5.5** For children, CT chest is used primarily to identify vascular injury. It should be performed for the following indications:
- 5.5.1 Suspected aortic injuries, as suggested by mechanism of injury, physical examination, or findings on CXR (first rib fracture (6), widened mediastinum, obscured aortic knob, left apical cap, or large left haemothorax).
- 5.5.2 Signs of great vessel injury (such as asymmetric, diminished, or absent peripheral pulses or paraplegia).
- 5.5.3 Suspicion for tracheobronchial injury.
- 5.6** The investigation of children with suspected non-accidental thoracic injury should be no different from the imaging used for accidental injury.
- 5.7** Although CT scanning has a greater sensitivity than plain X-ray for the detection of rib (vertebral and scapular) fractures, there is currently insufficient evidence of which children would benefit. However, chest CT should be considered if non-accidental injury is suspected and there is doubt regarding the nature of the rib abnormality identified on chest X-ray.
- 5.8** Echocardiography should be performed for children with chest trauma with physical findings concerning for cardiac injury (such as muffled heart noises or arrhythmias), elevated troponin levels, or abnormal ECGs.

6. Imaging of the abdomen and pelvis in the injured child

- 6.1** Contrast-enhanced CT scan is the imaging modality of choice for the assessment of acute traumatic intra-abdominal injury. Abdominal ultrasound has only modest sensitivity in detecting haemoperitoneum in children, and should not be performed if it would delay transfer to CT.
- 6.2** Decisions to perform an abdominal CT should be made on the basis of the clinical history and examination.
- 6.3** The following clinical variables have been found to be associated with intra-abdominal injury and may indicate the need for abdominal CT scan:
- 6.3.1 Lap belt or handlebar injuries; evidence of duodenal or pancreatic injury as part of Seat Belt Syndrome should lead to review of imaging of the thoracolumbar junction of the spine for evidence of a Chance fracture (5) (see 4.5).
 - 6.3.2 Abdominal wall bruising or discolouration;
 - 6.3.3 Abdominal tenderness in a conscious patient;
 - 6.3.4 Abdominal distension;
 - 6.3.5 Clinical evidence of persistent hypovolaemia, e.g. persistent unexplained tachycardia;
 - 6.3.6 Blood from the nasogastric tube or rectum.
- 6.4** Special consideration may need to be given to children who are intubated prior to hospital assessment or require transfer to the PMTC.
- 6.5** Abdominal injuries are rare where there is neurological impairment in the absence of abdominal signs and symptoms.
- 6.6** A normal CT scan strongly predicts the lack of subsequent deterioration of a patient's condition.
- 6.7** Pelvic fractures are rare in children, so a screening pelvic X-ray is not indicated.
- 6.8** Pelvic imaging should only be considered if there is concern after clinical assessment. Presence of a pelvic binder is not an indication in isolation without clinical assessment.

- 6.9** Pelvic fractures can be associated with multi-organ injury. The bony pelvis will be included on CT evaluation of the abdomen and pelvis. Where clinically indicated, contrast-enhanced CT of the abdomen and pelvis is the modality of choice.

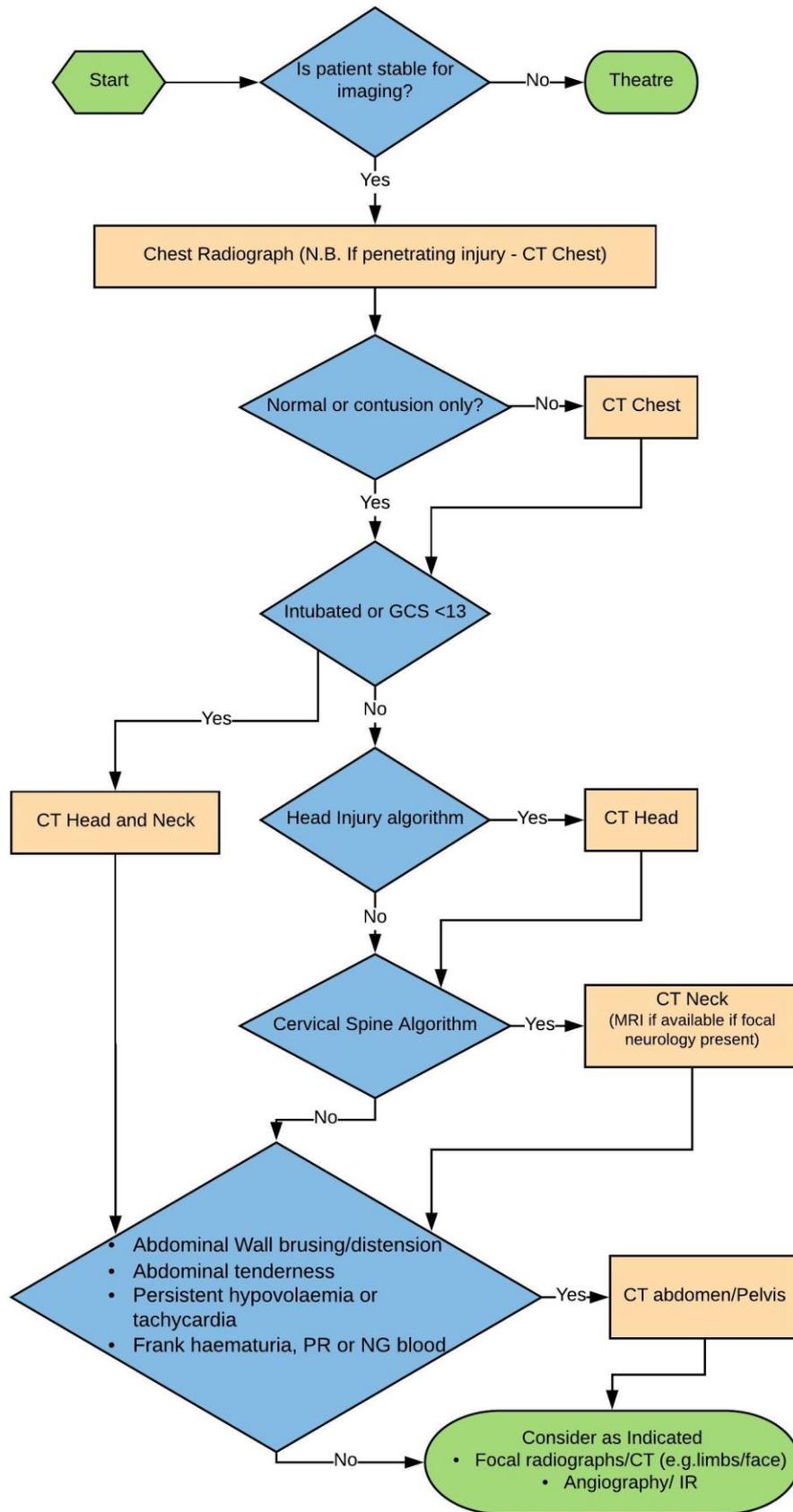
7. Imaging of limbs in the injured child

- 7.1** Clinicians should request plain X-rays of the injured region as the primary investigation, based on the history and clinical assessment.
- 7.2** Radiographs of injured limbs will usually be anteroposterior and lateral views, including the adjacent joints.
- 7.3** CT scanning may be required for more complex fractures and injuries of limbs.
- 7.4** Imaging of the limbs forms the largest part of the skeletal survey in cases of suspected non-accidental injury. In these cases, the imaging should be performed by 2 radiographers with documented education and training in paediatric and forensic radiography techniques (4). It should also be undertaken in a child friendly environment within a radiology department that is equipped for paediatric imaging and consist of a standard set of views.
- 7.5** Effective immobilisation is essential to obtain good quality images for a skeletal survey. This usually involves the child being held by an adult, either an appropriate family member or a professional. As the skeletal survey can be distressing, sedation of the child may be helpful.

8. Imaging of the whole body in the injured child

- 8.1** Whole body CT (WBCT or “Pan scan”) consisting of a vertex-to-toes scanogram followed by CT from vertex to mid-thigh, i.e. CT scanning of head, cervical spine, chest, abdomen and pelvis, is performed less often in children than adults (7), and is performed less often in stand-alone PMTCs or TUs than mixed or adult-only MTCs (8).
- 8.2** There is no single clinical variable that can be used as a sole indicator for WBCT in paediatric multi-trauma cases (9). WBCT should not be used routinely to image children under 16 years (10).
- 8.3** The indication to perform a WBCT in children with multi-trauma should be based on a clinical assessment by a senior clinician, in discussion with a senior radiologist. A flow diagram for the clinical decision-making is shown below (Fig. 3)
- 8.4** In a child with multi-trauma, who is stable enough not to require direct admission to the operating theatre for Damage Control Surgery (DCS), the mechanism of injury, e.g. high speed road traffic accident with rapid deceleration, fall from a significant height, may suggest the need for a WBCT (see Appendix 2).
- 8.5** The threshold for WBCT may be lower in the unconscious child or those intubated prior to hospital assessment (see Appendix 2), especially if there is evidence to perform CT scans of the head, cervical spine, abdomen and pelvis.

Fig 3. Whole Body CT scanning flow diagram



9. Interventional radiology for the injured child

- 9.1 The requirement for and use of Interventional Radiology (IR) in children with major trauma is relatively rare (11). It is usually limited to endovascular techniques for aortic injuries, significant and active arterial injuries of abdominal solid organs, or of the femoral or iliac arteries in pelvic trauma, in which the risk to life is high (11).
- 9.2 Access to the smaller vascular structures in children can often preclude the use of IR as the appropriate sized equipment may not be available. Alternatively novel points of vascular access may be required in a “hybrid procedure” with an operating surgeon (12).
- 9.3 It is anticipated that IR in children would only be undertaken within the PMTC at BRHC, in co-ordination with the relevant specialist radiologists and other paediatric subspecialists. It should be available within 30 minutes of request (3).

10. Reporting and the transfer of images

- 10.1 For both TUs and the PMTC, radiology reports for trauma CT scans should be provided as a “hot” verbal report within 5 minutes of completion of the imaging. A detailed provisional radiological report should be documented and available within 1 hour (3).
- 10.2 Within 24 hours, all trauma CT scans performed at or transferred to the PMTC should be reported by a consultant paediatric radiologist / neuroradiologist and be available to the clinical teams.
- 10.3 Skeletal surveys should be reviewed by a radiologist with experience of reporting such studies within 24 hours in case repeat or additional views are necessary.
- 10.4 Two radiologists with at least 6 months of experience of specialist paediatric radiology training, including experience of suspected physical abuse in children, should provide a consensus report within 24 hours (4). For some TUs, this may require a networking solution either with the PMTC or with another TU.
- 10.5 For children undergoing secondary transfer from a TU to the PMTC, all relevant trauma imaging should be transferred electronically urgently via the relevant network radiology systems, such that images are available for review by the relevant subspecialists at the PMTC. At latest this transfer of images must have occurred by the time the child arrives at the PMTC. Given the time-critical nature of some of these secondary transfers, this will require all TUs and the PMTC to have 24/7 availability of radiographers who are able to undertake these image transfer procedures.

Glossary of Terms

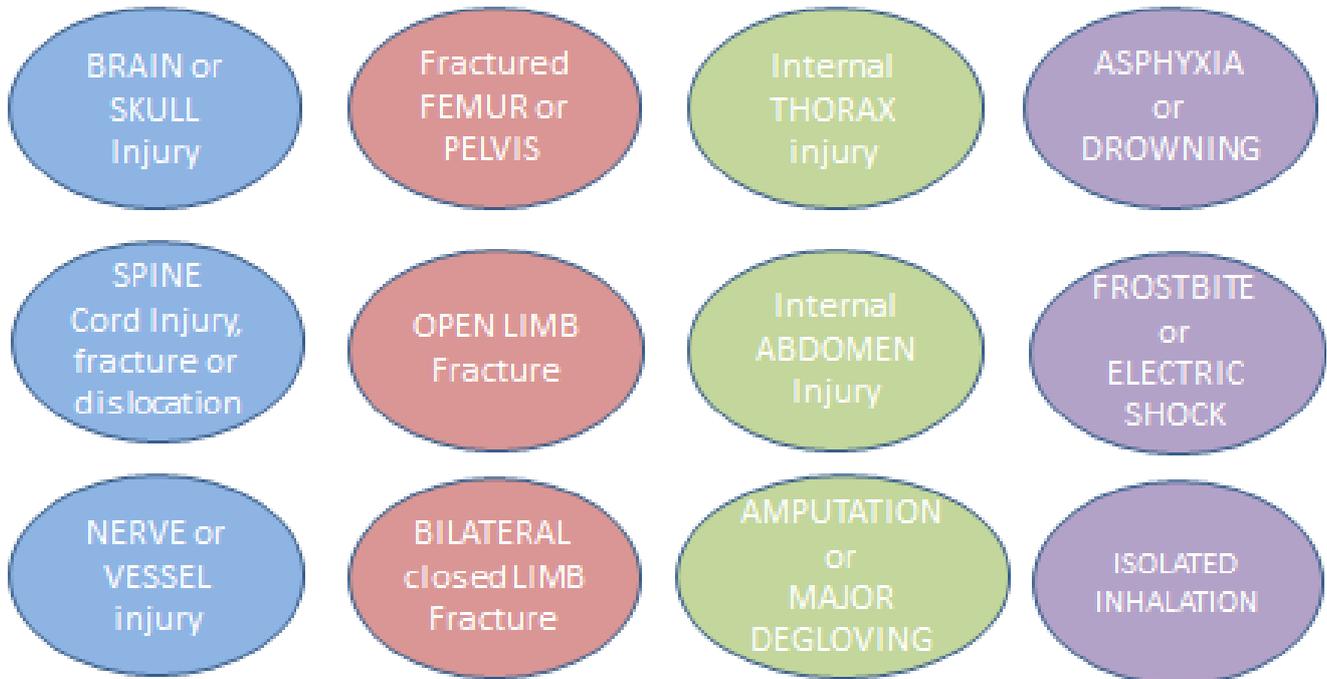
Abbreviation	Explanation
ALARA	As Low As Reasonably Achievable
BRHC	Bristol Royal Hospital for Children
CT	Computerised Tomography
CXR	Chest X-ray
DCS	Damage Control Surgery
IR	Interventional Radiology
MRI	Magnetic Resonance Imaging
MTC	Major Trauma Centre
PMTc	Paediatric Major Trauma Centre
TARN	Trauma Audit and Research Network
TU	Trauma Unit
WBCT	Whole Body Computerised Tomography

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<https://www.nice.org.uk/guidance/ng39/chapter/recommendations#management-of-haemorrhage-in-prehospital-and-hospital-settings>

Appendix 1.

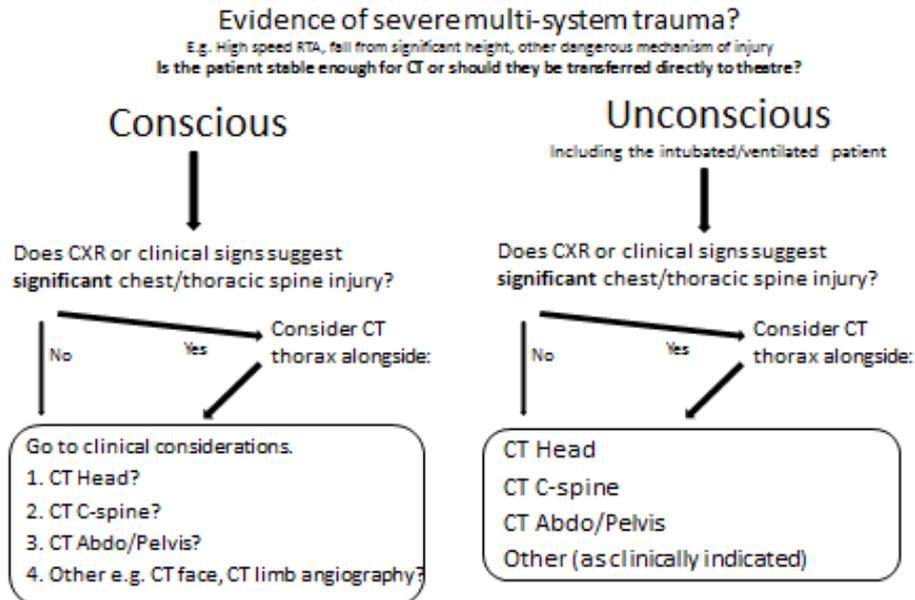
What is a “Paediatric Major Trauma” injury?



THIS ALSO INCLUDES NON-ACCIDENTAL INJURIES

Appendix 2.

Emergency Department Paediatric Major Trauma Imaging Tool



Box 1.

Clinical considerations:

1. CT Head

- Does the child meet criteria for NICE Head injury guideline?

2. CT C-spine

- If there is neurological deficit MRI should be modality of choice if available.
- In conscious patients under 8 years old with C-spine concerns, C1/2 C-spine CT imaging may be indicated in addition to initial radiographs. This is due to higher risk of upper C-spine injury and likely lack of sufficient PEG view.

3. CT Thorax

- Is the imaging modality of choice in penetrating chest injury.

4. CT Abdomen/Pelvis

- A primary survey pelvic X-ray is not indicated in the paediatric population.
- Signs of concern: Abdominal wall bruising/ distention; Seatbelt injury; Persistent hypovolaemia or tachycardia; PR or NG blood, frank haematuria