Symposium

Imaging of a Child with Polytrauma

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ABSTRACT
Trauma is the cause of over 45% of deaths in children aged 1 to 14 years. Children are susceptible to polytrauma, as the body of a child has higher elasticity and adverse body size-weight ratio, which allows for a greater distribution of traumatic injuries. The emergency physician or pediatrician manages a polytrauma child by an initial primary survey with an objective to identify and address immediate life-threatening injuries and a secondary survey to provide definitive treatment. Emergency radiology plays a crucial role in the management of a polytrauma child. Several imaging techniques are available, each one with its own advantages and limits and the radiologist should promptly decide which modality to use as to obtain maximum useful information to develop an appropriate treatment and/or surgical plan. The sensitivity of a radiological investigation for polytrauma is more important than its specificity with the primary aim of not missing any critical finding which is life-threatening. X-ray is the first important modality in primary survey, Focused assessment with sonography in trauma (FAST) and extended FAST (e-FAST) have crucial role in hemodynamically unstable patients, whole-body computerized tomography (CT) is a diagnostic aid of the secondary survey and Magnetic resonance imaging (MRI) plays a pivotal role in patients with diffuse axonal injury and spinal trauma.

Key words: Pediatric Polytrauma, Primary survey, Secondary survey, FAST, CT, MRI

Introduction
Pediatric injuries are the major cause of mortality and disability worldwide and about 5 million children die from trauma each year. Although many studies were conducted on the epidemiology of pediatric trauma, Kundal et al., in their study on epidemiology of pediatric trauma and its pattern in urban India, found that road traffic injury was the most common mode of trauma, followed by fall related injuries, thermal injuries and assault as other causes in their study. Study of Sharma et al. revealed that falls were the leading cause of trauma in all age groups, followed by road traffic injury. The other causes also include child abuse, drowning and homicide/suicides. This helps us in working on preventive factors to reduce the pediatric trauma.

An optimal pediatric care in a child with trauma requires understanding of some important anatomical, physiological, and psychological differences between a child and an adult patient. Anatomically, imbalance between larger body surface and weight of child allows for greater distribution of injuries resulting in polytrauma. Higher body elasticity, less subcutaneous fat and muscular protection leads to severe internal injuries without any recognizable external signs. Physiologically, child’s greater relative body surface causes greater heat loss and this fact needs consideration during water and electrolyte maintenance. Psychologically, children are excessively irritable, making their assessment even more difficult.

Pediatric polytrauma management
The management of a child with polytrauma includes a primary and a secondary survey. Primary survey has objective to identify immediate life-threatening injuries. The initial assessment should be rapid (5–10 min) and a logical sequence should be followed; A–B–C–D–E (airway – breathing – circulation – disability – exposure). Secondary survey aims to assess and provide definitive treatment after total stability of the vital parameters.

Role of radiologist and Imaging in pediatric polytrauma management
As a member of the trauma team, the radiologist contributes with the help of appropriate imaging modalities in the rapid diagnosis of traumatic injuries, as time is one of the most relevant factors for the
survival of injured child. Several imaging techniques are available; each one with its own advantages and limits (Table 1). In an emergency management, the sensitivity of a radiological investigation is more important than its specificity with the primary aim of excluding any morbid condition which may require prompt treatment.

### Table 1: Advantages/disadvantages of imaging modalities

<table>
<thead>
<tr>
<th>Imaging modality</th>
<th>Advantages</th>
<th>Disadvantages</th>
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<tbody>
<tr>
<td>X-ray</td>
<td>Very accessible</td>
<td>2D images</td>
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<tr>
<td></td>
<td>Rapid</td>
<td>Artifact from superimposed structures</td>
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<td></td>
<td>Low cost</td>
<td>Limited use for soft tissues</td>
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<tr>
<td>Ultrasound</td>
<td>Generally accessible</td>
<td>Operator dependence</td>
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<tr>
<td>FAST</td>
<td>No ionizing radiation</td>
<td>Limited by body habitus</td>
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<tr>
<td>E-FAST</td>
<td>Low cost</td>
<td>Potentially painful</td>
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<tr>
<td></td>
<td>Dynamic image capture</td>
<td>Inconclusive results</td>
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<td></td>
<td>Procedural guidance</td>
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<tr>
<td></td>
<td>Bedside test</td>
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<tr>
<td>Computed tomography</td>
<td>Generally accessible</td>
<td>Ionizing radiation</td>
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<tr>
<td>(CT)</td>
<td>Rapid</td>
<td>Contrast-induced nephropathy</td>
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<tr>
<td></td>
<td>High specificity/sensitivity</td>
<td>Intermediate cost</td>
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<td></td>
<td>3D images</td>
<td>Contrast allergy</td>
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<tr>
<td>Magnetic resonance</td>
<td>No ionizing radiation</td>
<td>High cost</td>
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<tr>
<td>Imaging (MRI)</td>
<td>High specificity/sensitivity</td>
<td>Limited availability</td>
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<tr>
<td></td>
<td>No contrast nephropathy</td>
<td>Long study duration</td>
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<td></td>
<td></td>
<td>May require sedation for children or cause claustrophobia</td>
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**Choice of imaging modality**

Imaging to be performed during primary survey stage are chest X-ray-AP view, cervical spine X-ray-lateral view, pelvis X-ray-anteroposterior view, and e-FAST ultrasound scan (extended focused assessment with sonography for trauma). CT is a diagnostic aid of the secondary survey for complete evaluation.

In hemodynamically stable patients or in patients stabilized after primary resuscitation, CT scan can be performed for a detailed exam of all the body parts; on the contrary, in hemodynamically unstable patients, ultrasound (FAST/e-FAST) is done during the primary survey. The Royal College of Radiologists (RCR) guidelines for the severely injured patient (2010) state that “Focused assessment with sonography for trauma (FAST) does not offer any additional information to that obtained with a CT scan and should not be performed if it would delay transfer to CT”.

**FAST and E-FAST**

FAST (Focused assessment with sonography for trauma) was first described in the early 1970s as an adjunct for injured evaluation in emergency department and usually performed bedside. It can also be used for rapid triaging of multiple individuals in mass casualty situations. Guidelines for FAST examination have been published by the American Institute of Ultrasound in Medicine (AIUM) and the American College of Emergency Physicians (ACEP). The primary ultrasound windows for the FAST examination include the following: (1) The Right Upper Quadrant / Perihepatic View. (2) The Left Upper Quadrant/ Perisplenic View. (3) The Pelvic/Retrovesical View. (4) The Pericardial / Sub-xiphoid View. This has been shown in [figure 1 & 2](#). Today, in its extended form, E-FAST additionally allows for rapid evaluation of the chest for detection of pneumothorax. Finally, some clinicians incorporate inferior vena cava evaluation into the FAST
examination to help determine a patient's volume status and fluid responsiveness. There are limitations to FAST assessment in its ability to detect free fluid in patients with mesenteric or hollow viscous injury, isolated penetrating injury to the peritoneum and in identifying retroperitoneal hemorrhage. It is important to note, however, that the FAST examination is a screening test, and false-negative examinations do occur. False-positive examinations may also be encountered in patients with a history of ascites, preexisting pericardial and pleural fluid. The study by Ben-Ishay et al. shows that although a positive FAST evaluation does not necessarily correlate with an intra-abdominal injury (IAI), a negative one strongly suggests the absence of an IAI, with a high negative predictive value.

Role of CT scan imaging in polytrauma:
The advantage of a CT scan; in a setting of polytrauma, lies with the fact that it is less operator dependent and has high sensitivity and specificity. Unenhanced scans are appropriate for the assessment of head and face injuries. The contrast-enhanced CT includes the examination of the neck, thorax, abdomen, and pelvis. It is generally a multi-phasic study with an arterial phase to diagnose vascular injuries, a portal venous phase to diagnose solid organ injuries and the presence of free fluid in the peritoneal cavity, and a late excretory phase if required in suspected injuries of the urinary system. The coronal and sagittal multiplanar reconstructions (MPR), maximum intensity projections (MIP) and volume rendering (VR) reconstructions are required to assess vascular injuries, spinal/bony fractures and evaluate solid organs.

Role of MR imaging in polytrauma:
A polytrauma child with neurological symptoms, not completely explained by CT imaging, MRI must be performed. Among all post-traumatic intracranial pathologies, the diagnosis of diffuse axonal injury remains more complex. Initially the CT is normal (50–80 %) and MRI is recommended to detect it in early phase. In fact, about 30 % of initial negative CTs are positive on MRI.

Pediatric Head Injuries: PHI
In children, the area more frequently affected by trauma is the skull. PHI is classified as traumatic or accidental brain injury (TBI) and non-accidental head injury. It includes scalp hematoma, laceration, skull fracture, epidural or subdural hematomas, cerebral contusion, penetrating injuries and DAI. CT is the primary investigation for cranial imaging in head trauma. Evidence suggests that patients can be safely discharged home after negative findings on CT provided that the patients are neurologically normal.

According to the ACR–ASNR Practice Guideline for
the Performance of Computed Tomography of the Brain, a 3mm thick CT scan from C3 vertebral body to vertex with MDCT-MPR reconstruction with bone windows should be recommended in the paediatric management.16

According to the Pediatric trauma protocols illustrated by the Royal College of Radiologists (RCR) 17, the guidelines summarized by the National Institute for Health and Care Excellence (NICE) 2014 17 are followed in selection of children with trauma for a CT head scan. This is presented as an algorithm in figure 3.

Emergency department: child with head injury

Any of following risk factors present?

1. Initial assessment: GCS<14 or if age < 1 year and GCS<15.
2. At 2 hours after injury; GCS<15.
3. Suspected open or depressed skull injury or tense fontanelle.
4. Signs of basal skull fracture.
5. Focal neurological deficit.
6. Post traumatic seizure (no history of epilepsy).
7. Suspicion of non-accidental injury.
8. Children < 1 year: any skull bruise, laceration or swelling < 5cm

YES

PROCEED FOR CT SCAN

NO

See for these risk factors if present

1. Loss of consciousness > 5 minutes.
2. Abnormal drowsiness.
3. 3 or more episodes of vomiting.
4. Amnesia > 5 minutes.
5. Dangerous mechanism of injury: high-speed injury/ fall from height > 3 mtrs.

1 RISK FACTOR

1 RISK FACTOR ONLY

Observe for 4 hours
If further episodes of vomiting, abnormal drowsiness or GCS<15.

PROCEED FOR CT SCAN

NO RISK FACTOR

But child on Warfarin treatment:

PROCEED FOR CT SCAN
(within 8 hrs of injury)

EDH from SDH on CT or MRI. EDH is shown in figure 4. Skull fractures are easily detected on CT on the bone window settings and may be even diagnosed on X-ray skull. The target on CT imaging is to detect the presence of fracture, its location and type (simple linear, midline, occipital, multiple, complex, diastatic or depressed fractures). This is shown in figure 5.

Figure 4: (a) Plain CT head shows a thin hyperdense EDH in left frontal region. (b) Bone window shows skull fracture of adjacent bone (white arrow).

Figure 5: Axial CT head shows depressed skull fracture of right temporo-parietal bone with overlying scalp hematoma, well demonstrated on reconstructed VRT image.

Subdural haematoma (SDH) is secondary to torn cortical vein or sinus and on CT typically appears as crescent shaped hyperdense collection along the calvarium in acute stage. This is shown in figure 6.

Figure 6: Plain CT head shows a thin crescentic hyperdense SDH along left fronto-temporal convexity (black arrow) with coronal sutureal diastasis (white arrow), well demonstrated on reconstructed VRT image.
Subarachnoid hemorrhage (SAH) on CT is seen as hyperdensity into the subarachnoid space, basal subarachnoid or sellar cisterns and sylvian fissures. A small amount of SAH could be missed on CT, but MRI with FLAIR sequence can detect subtle SAH. SAH is shown in figure 7.

Cerebral edema is a bad prognostic sign and usually results in cerebral dysfunction. There are two typical signs on CT: the 'reversal sign' showing diffuse loss of grey–white matter differentiation with decreased attenuation of the cortex and the 'white cerebellum sign' showing hyperdense brainstem and cerebellum due to their relative sparing. Reversal sign is shown in figure 7.

Diffuse axonal injury (DAI) is diagnosed in children with high-impact head trauma. It is a diagnosis of exclusion whereby the child presenting with a definite history of trauma who has a low GCS at presentation but yet a 'normal' brain CT. MRI is a more reliable modality and appears as a small parenchymal subcortical hyperintensity alteration, depicted on FLAIR and diffusion-weighted sequences. This is shown in figure 8.

Pediatric Thoracic Injuries
In younger children, 60 to 80% of chest injuries are the result of blunt trauma, however; in adolescents, penetrating trauma has a statistically more prominent role. Antero-posterior (AP) chest radiograph still remains a cost-effective first-line tool in the imaging workup. They can be acquired rapidly and provide information about pulmonary lesions, pneumothorax, hemothorax, mediastinal lesions, etc. Multi-detector computed tomography (MDCT) is more sensitive than chest radiography for a multitude of chest injuries such as rib fractures, pneumothorax, hemothorax, lung contusions, lacerations, diaphragmatic rupture, and aortic injuries (especially in penetrating chest trauma). In hemodynamically unstable patients, ultrasound by e-FAST technique is extremely useful to rule out hemothorax and pneumothorax or to guide interventional procedures.

Lung parenchymal injuries include contusions, pneumatoceles and lacerations. Pulmonary contusions are the most common finding in blunt chest trauma and can be more reliably demonstrated on CT as peripherally located ground-glass or consolidative airspace opacities. Pneumatoceles appear as round collections of air. Pulmonary lacerations on CT appear as linear areas of parenchymal lucency. These are shown in figure 9 & 10.

Pleural space abnormalities include pneumothorax, hemothorax and chylothorax. Pneumothorax occurs when air enters the pleural space from pulmonary, chest wall, esophageal or tracheobronchial tree injuries and occurs in 33% of pediatric thoracic traumas. In upright position, the diagnosis on chest radiograph is based on the identification of the visceral pleura seen as “pleural line”, and the complete absence of pulmonary pattern laterally to the pleural line. To detect a pneumothorax in supine position, deep sulcus sign is seen on AP chest radiograph, which represents
lucency of the deepened lateral costophrenic angle extending toward the hypochondrium giving it a very sharp appearance. CT is more sensitive than chest radiography for small pneumothoraces. The most concerning adverse outcome of pneumothorax is progression to a tension pneumothorax indicated by mediastinal shift to the contralateral side, depression of the ipsilateral diaphragm, and rapid expansion on serial radiographs. Pneumothorax is shown in figure 9 & 10.

Figure 9: Chest radiograph (a) shows bilateral diffuse haziness, representing lung contusions which are seen as diffuse bilateral airspace consolidations with lacerations (black arrow) on reformatted coronal CT chest (b). Axial CT lung window (c) shows bilateral contusions with left sided pneumothorax (white arrow).

Figure 10: (a) Axial CT chest shows bilateral hemothorax with lung contusions with hemato-pneumatocele (black arrow). (b) Axial CT lung window shows bilateral contusions with left sided pneumothorax (white arrow).

**Hemothorax** is the result of bleeding into the pleural cavity and occurs in about 13% of pediatric thoracic traumas. On supine chest radiography, it manifests as a veil like increased density over the involved hemothorax. On e-FAST, it is seen as echogenic pleural effusion. At CT, it appears as a high-attenuation pleural fluid (50 to 80 HU). This is shown in figure 11.

**Chylothorax** is a collection of lymphatic fluid within the pleural space due to thoracic duct injury and requires fluid sampling to confirm the diagnosis.

Figure 11: Axial CT chest shows bilateral hemothorax with right chest tube (white arrow) with left pneumatocele.

**Pneumomediastinum** (free air within the mediastinum) is seen in 5–10% of pediatric thoracic traumas. It may be caused by direct penetrating injury, tracheobronchial or esophageal rupture. Pneumomediastinum does not always indicate thoracic injury; extra-thoracic causes include head and neck trauma as well as sub-diaphragmatic pathology. At chest radiography, pneumomediastinum can manifest as mediastinal linear lucencies, or as the “continuous diaphragm” sign, caused by air outlining the superior diaphragmatic surface. CT is more reliable in demonstrating even subtle pneumomediastinum and differentiating it from pneumothorax.

**Esophageal injury** is rarely seen after chest trauma in children (<0.1%). On CT features of pneumomediastinum and left-sided pleural effusion are seen. The diagnosis further requires a contrast esophagogram or bronchoscopy. **Tracheobronchial injuries**, are fortunately rare in children with chest trauma (<1%). On imaging, these patients show persistent pneumothorax and/or pneumomediastinum, even in the presence of a well-functioning chest tube with subcutaneous emphysema.

**Aortic injury** is very rare, occurring in < 0.1% of pediatric thoracic traumas but has high mortality. On chest radiograph, imaging findings include obliterated contour of the aortic arch, deviation of trachea to the right, downward depression of the left mainstem...
bronchus and widening of the paravertebral and paratracheal stripes signifying mediastinal hematoma. The most common site of aortic tear is the isthmus, distal to the origin of the left subclavian artery and MDCT shows a pseudoaneurysm located on the anterior aspect of the proximal descending aorta, periaortic hematoma, intimal flaps, luminal clots, and active contrast extravasation.

**Diaphragmatic injury** or rupture is seen in 1–5 % of pediatric thoracic trauma. As a consequence, intra-abdominal viscera may herniate into the thoracic cavity. Radiographic findings may include apparent elevation of a hemidiaphragm and gas-filled stomach or bowel loops located within the chest. MDCT allows to delineate the exact site of the diaphragmatic tear (seen as interruption) and to establish herniated abdominal viscera with *hourglass or collar sign*.

**Chest wall injuries** include rib and sternal fractures and thoracic spine injuries. Rib fractures occur less frequently than in adults, as pediatric chest wall has greater flexibility due to increased ligamentous laxity and less rib mineralization. Pediatric ribs typically bend instead of breaking when compressed. When non-displaced, rib fractures are very difficult to diagnose on an AP chest radiograph and CT is more sensitive in identifying them, well demonstrated by the volume rendered technique (VRT). This is shown in figure 12.

![Figure 12: VRT reconstructed image shows multiple right rib fractures (white arrows) and left clavicle fracture (black arrow).](image)

**Thoracic spine injuries** include vertebrae fractures and spinal cord injuries. Vertebral body compression fractures are best documented on lateral spine radiographs or sagittal reformatted CT images. MRI is useful in the setting of spinal cord injury. This is shown in figure 13.

![Figure 13: Sagittal T2W MRI shows vertical fracture of D5 vertebra (white arrow) with spinal cord edema/injury (black arrow).](image)

**Pediatric Abdominal Injuries**

Abdominal trauma is the second most common site of injury after head trauma. According to the dynamics of injury, high- and low-energy trauma cases are encountered. Low energy trauma cases are investigated by x-ray, ultrasound and contrast enhanced ultrasound (CEUS). High energy trauma cases are divided into hemodynamically unstable patients evaluated by e-FAST and stable patients investigated by contrast enhanced CT (CECT).

CECT abdomen is the modality of choice for assessment of acute traumatic intra-abdominal injuries. The clinical indications include: lap belt or handle bar injuries, abdominal wall ecchymosis, abdominal tenderness, abdominal distention, persistent unexplained tachycardia and blood from rectum or nasogastric tube.

*The imaging findings to look for on CT imaging are: hemoperitoneum, pneumoperitoneum, contrast blush consistent with active bleeding, solid organ injury (laceration, contusion, parenchymal/ subcapsular...*
Hepatic injury is found in 10–30% of blunt abdominal trauma. In many statistics, liver is considered to be the organ which is mostly involved. Lacerations on CT appear as linear hypodense areas and contusions as ill-defined vague hypodense areas. Hematomas on plain scan appear as fuzzy hyperdense areas and on CECT will appear hypodense compared to the normal enhanced parenchyma. Hepatic injury is associated with hemoperitoneum in approximately two thirds of cases. The most widely used grading scale to quantify the severity of hepatic injury was developed by the American Association for the Surgery of Trauma (AAST). Hemoperitoneum is seen as high density fluid in the peritoneal cavity, around 40 HU. Hepatic injury is shown in figure 14.

Figure 14: CECT abdomen (a & b) shows hepatic lacerations & hematoma (white arrows). Hemoperitoneum (black arrows) is seen on CT (a) as hyperdense fluid and on FAST (c) as free fluid in peritoneal cavity with echoes.

Splenic injury is common and found in 25% of blunt abdominal trauma; both as isolated and as multiorgan lesions. They are often associated with hemoperitoneum in case of splenic capsule rupture, or seen as subcapsular or intraparenchymal hematoma, if the capsule is undamaged. This is shown in figure 15.

Figure 15: CECT abdomen shows splenic lacerations as linear non-enhancing hypodense areas (white arrows).

Renal trauma is relatively frequent in children and is the third most involved organ in blunt abdominal trauma. It includes injury to kidneys, external genitals, bladder, urethra, and ureter. Imaging includes assessment of renal parenchymal, vascular and collecting system injuries. The most common renal injury is parenchymal contusion, which is manifested on CT by a focal or diffuse region of delayed contrast enhancement. The involved kidney may appear larger due to edema with subcapsular or perinephric hematoma. A segmental renal infarct appears like a peripheral wedged-shaped nonenhancing area. Renal collecting system injury result in urinary extravasation of IV contrast, called as an “urinoma” when contained in the perirenal space. Delayed scan done 10–15 minutes after IV contrast administration may be useful in detecting such extravasation. Imaging of the bladder is evaluated by CT cystography and performed by filling the bladder retrogradely with contrast medium. Adrenal injuries are more frequent in high-energy trauma, usually unilateral (>90%) and seen as hyperdense hematoma on plain CT imaging. Renal and adrenal injuries are shown in figure 16.

Figure 16: CECT shows: (a) left renal parenchymal contusion (white arrow) with perinephric hematoma. (b) Left renal subcapsular hematoma with pseudoaneurysm (black arrow). (c) Right adrenal contrast blush suggestive of active adrenal bleed (curved arrow).

Pancreatic injury is seen in 3–12% of blunt abdominal trauma and is more common in children than adults, as pancreas is less protected due to relatively reduced abdominal musculature and...
adipose tissue. CT shows linear intrapancreatic hypodense areas suggestive of pancreatic tear, while separated glandular fragments will appear in pancreatic transections. The best indicator of pancreatic injury at CT is unexplained peripancreatic or anterior pararenal space or lesser sac fluid. Additional CT signs include focal or diffuse gland enlargement, stranding of peripancreatic or mesenteric fat, thickening of the anterior renal fascia, and free peritoneal fluid. This is shown in figure 17.

Figure 17: CECT abdomen shows pancreatic neck injury/transection (white arrow), peripancreatic collection (black arrow) communicating with pancreatic duct (*).

Vascular injury is common with pelvic fractures. CT imaging can not only detect vascular injury but also, in many cases, it can differentiate if it is venous or arterial, and locate the damaged vessel providing the road map needed for vascular embolization management. Active contrast blush on CT signifies differential diagnosis of active arterial extravasation, post-traumatic pseudoaneurysm and A-V fistula. A contrast “blush,” is defined as high attenuation areas (> 90 HU) after IV contrast enhancement. This is shown in figure 16 & 18.

Bowel injury is uncommon in pediatric blunt trauma. Specific imaging signs on CT include visualization of tear of the intestinal wall, presence of free extraluminal air and “unexplained” peritoneal fluid in the absence of solid viscus injury or pelvic fracture. The leakage of the oral contrast outside of the intestinal lumen is a highly specific sign, though rarely seen. Non-specific imaging signs of bowel or mesenteric injury include mesenteric hematoma and fat stranding.

Hypoperfusion complex presents as a complex set of imaging findings on CT, which a radiologist must recognize. These include: caliber reduction of the aorta and IVC, thickened and irregular enhancement of the bowel wall (shock bowel) and considerable enhancement of the mesentery, kidneys, and adrenal glands and periportal hypodensity.

Pediatric Musculoskeletal Injuries
Around 10–15 % of the overall pediatric traumas are represented by musculoskeletal injuries. Potential spine injuries should be assessed on a case-by-case basis and clinical assessment should underpin the investigations. Plain radiographs of the injured region are the first step and technique of choice for the study of the bony injuries (figure 19). When indicated, targeted CT of an area may be required for further assessment. Ultrasound and MRI are the main imaging modalities in approaching issues concerning tendons, ligaments, muscles, and osteochondral cartilage. When there are definitive neurological signs, the primary imaging modality should be MRI wherever available.

Figure 18: 11-year-old child with pelvic trauma: CECT abdomen shows hemoperitoneum (*) with active contrast blush (black arrows).

Figure 19: X-ray left leg shows displaced fracture of mid shaft of left femur with overlying slab.
Symposium
Diagnostic Imaging in Child Abuse
Child abuse is an issue of great relevance and the main forms being neglect, physical abuse, sexual abuse, and psychologic abuse. Previously battered child syndrome was the term used to describe injuries typical of abuse. It is also known as non-accidental injury (NAI) and imaging plays an important role in its detection and differentiating it from abuse from other causes. Metaphyseal microfracture is virtually pathognomonic of abuse and X-ray showslucent area extending perpendicularly across metaphysis signifying microfractures. Rib fractures in infants are strongly correlated with abuse and most commonly seen posteriorly. In case of strong suspicion of NAI, it is necessary to perform a complete X-ray skeletal survey for the detection of occult fractures. Radioisotope bone scan is extremely sensitive in the identification of microfractures invisible or hardly detectable on X-ray. SDH, SAH, DAI and diffuse cerebral edema are common non-accidental head injuries (NAHI). The combined use of CT and MRI allows a more accurate detection and characterization of intracranial lesions in cases of NAHI.

Role of interventional radiology
Interventional radiology plays a cornerstone role in the management of paediatric trauma. In the acute setting, interventional radiology techniques allow minimally invasive control of hemorrhage or re-establishment of blood flow. Percutaneous stenting and drainage can allow disruptions in urinary or biliary systems to heal without the need for further surgery. There is a significant role in treating delayed complications of trauma, including embolization of arterial pseudoaneurysms.

Imaging radiation considerations: concept of ALARA
The increased risk from ionizing radiation during imaging (X-rays and CT) in children is due to number of factors. Developing and maturing tissues in the growing child are more radiosensitive, there is a cumulative radiation risk over a lifetime, and they have longer lifetime to express the increased relative risk. Exposure to ionizing radiation should always be kept to a minimum and the “as low as reasonably achievable” (ALARA) principle should be adhered to. Several studies have demonstrated that low-dose CT protocol (children with a body mass of < 20 kg; mAs 100, 120 KV; children with a body mass of 20 kg and more: mAs 200, 120 KV, with an average current-exposure time product of 271 +/- 73) is a useful alternative to provide satisfactory image quality.

Medico-legal issues: pediatric polytrauma imaging
Informed consent represents a communication method that is ethically required before the beginning of any procedure or treatment and responsibility for ensuring this rests with the radiologist. Radiologists have the responsibility to adequately inform clinical colleagues and patients about the risks and benefits of radiologic examinations.

Conclusion
All children admitted to a pediatric trauma unit, should receive a high standard of appropriate and timely care. This relates both to clinical management and radiological imaging. Imaging and radiologist play a pivotal role, as a member of the emergency team in the diagnosis of injuries. Injury patterns in children differ vastly to those in adults; this important factor must be taken into account by the radiologist in deciding the most appropriate imaging modality, which is more sensitive than specific. Exposure to ionizing radiation should be governed with the principle of ALARA, with aim to provide good quality, informative imaging to exclude any morbid condition which is life-threatening and requires urgent treatment. The emphasis should be on judicious use of plain radiography, FAST and e-FAST in hemodynamically unstable patients and targeted use of CT with relevant pediatric protocols in hemodynamically stable patients.

Key points:
1. In an emergency management, the sensitivity of a radiological investigation is more important than its specificity with the primary aim of excluding any morbid condition which may require prompt treatment.
2. In hemodynamically stable patients, CT scan is performed for detailed examination; on the contrary, in hemodynamically unstable patients,
ultrasound (FAST/e-FAST) is done during the primary survey itself.

3. Exposure to ionizing radiation should always be kept to a minimum and the “as low as reasonably achievable” (ALARA) principle should be adhered to; with aim to provide good quality and informative imaging.

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