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Appropriate Use of Diagnostic Imaging for Evaluating Common Pediatric Conditions

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I have no financial disclosures or commercial interests.

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Basic Principles

- Children are more vulnerable to radiation than adults – greatest effect on actively growing cells.
- Induction of solid cancer may take decades, so radiation exposure is more of a concern in children given their longer potential lifetime.
- Similar exposure levels between adults and children can result in a higher dose given the smaller cross-sectional area in children.
- ALARA – As Low As Reasonably Achievable

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Basic Principles

- Ionizing radiation is used in radiography, fluoroscopy, angiography, and CT scanning.
- It is reasonable to act on the assumption that low-level radiation may have a small risk of causing cancer.
- Benefits of an indicated CT scan far outweigh the risks.
- Properly performed CT examinations of children should expose a child to much lower exposures than those for the same procedure on an adult.

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- Be every child's advocate.
- Direct parents to the website.
- Only order an indicated exam.

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TABLE 1 Estimated Medical Radiation Doses for a 5-Year-Old Child

Imaging Area	Effective Dose, mSv	Equivalent No. of CXRs
3-view ankle	0.0015	1/14th
2-view chest	0.02	1
Anteroposterior and lateral abdomen	0.05	2½
Tc-99m[2] radionuclide cystogram	0.18	9
Tc-99m radionuclide bone scan	6.2	310
FDG PET[3] scan	15.3	765
Fluoroscopic cystogram	0.33	16
Head CT	4	200
Chest CT	3	150
Abdomen CT	5	250

Radiation Risk to Children From Computed Tomography
Alan S. Brody, Donald P. Frush, Walter Huda and Robert L. Brent
Pediatrics 2007;120;677

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Imaging Work-up of Common Clinical Scenarios

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Acutely Limping Child Up To Age 5

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Acutely Limping Child Up To Age 5

- Acute onset of limp or refusal to walk is a common complaint in children.
- DDx depends on the presence of signs of infection, localization of pain, and history of trauma.
- When symptoms cannot be localized, coverage of wider anatomic areas may have more diagnostic value.

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Acutely Limping Child Up To Age 5 – Nonlocalized Sx, No Concern for Infection

- Most common noninfectious etiology is a minor traumatic injury.
- Younger children cannot accurately localize pain to one focal area leading to ⇧imaging (pelvis through feet).
- Spiral tibial fxs are most common in children under age 4.
- Recommendation: Radiographs of tibia/fibula is usually appropriate for initial imaging of children up to age 5 with acute limp, nonlocalized symptoms, and no concern for infection.

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Acutely Limping Child Up To Age 5 – Nonlocalized Sx, Concern for Infection

- Fever, ⇧ WBC, ⇧ ESR, ⇧ CRP and limp should suggest possibility of infection.
- DDx includes septic arthritis, osteomyelitis, discitis, pyomyositis, LCH, and tumor.
- Radiographs - low yield.
- Recommendation: Lower extremity MRI is usually appropriate for initial imaging of children up to age 5 with acute limp, nonlocalized symptoms, and concern for infection.

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Acutely Limping Child Up To Age 5 – Localized to Hip, Concern for Infection

- Diagnosis is septic arthritis until proven otherwise.
- Most common cause of acute severe monoarticular pain in children.
- Results from hematogenous and intra-articular spread of S. aureus.
- Radiographs – low yield.
- Recommendation: US hips and/or MRI pelvis are usually appropriate for initial imaging of children up to age 5 with acute limp, symptoms localized to hip, and concern for infection.

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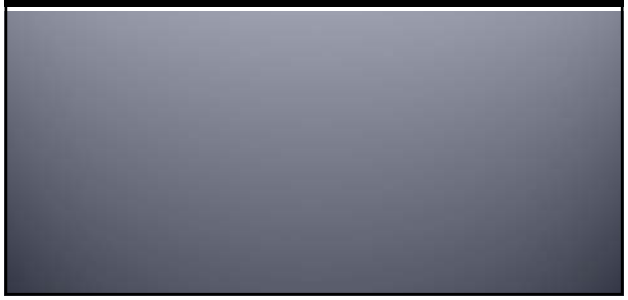
Head Trauma



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Head Trauma

- CT has traditionally been the primary imaging study for suspected TBI.
- MRI often requires sedation.
- Children are more likely to sustain calvarial fxs due to a larger craniofacial ratio and thinner skull.
- Up to 50% of intracranial injuries occur in the absence of fracture.
- Estimated 21% of fractures detectable by CT may be missed by radiographs.

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Minor Head Trauma

- Minor head injury usually refers to a patient with normal/near-normal post event mental status and GCS > 13.
- 3-5% of children have identifiable abnormalities by imaging.
- Less than 1% require neurosurgical intervention.

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Minor Head Trauma

- Pediatric Emergency Care Applied Research Network (PECARN) > 2 years
  - 99.9% NPV and 96.8% sensitivity for clinically important injury
  - normal mental status
  - no LOC, vomiting, severe mechanism, signs of basilar skull fx, or severe headache
- PECARN < 2 years
  - 100% NPV and sensitivity for TBI
  - normal mental status and acting normally per parents
  - no scalp hematoma (except frontal), LOC, severe mechanism, palpable skull fx

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Minor Head Trauma

- Recommendation:
  - Imaging is typically not indicated in children with minor head trauma and no signs or symptoms.
  - May be appropriate in younger children if clinical assessment is uncertain or indeterminate.

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Head Trauma with Neurologic Sxs Moderate to Severe Head Injury

- Moderate to severe head injury is typically associated with mental status changes.
- Greater incidence of intracranial injury in patients with decreased GCS.
- Shear injury or ischemia more likely.
- MRI has higher yield for prognosis (unlikely to detect neurosurgically relevant lesions missed by CT).

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Head Trauma with Neurologic Sxs Moderate to Severe Head Injury

- Recommendation:
  - Noncontrast CT.
  - MRI when clinical status is discordant with negative CT findings (also useful in suspected NAT).

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Urinary Tract Infection

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Urinary Tract Infection

- Most frequent serious bacterial infection during childhood (2% of boys and 8% of girls by age 7).
- Peaks during 1st year of life and between ages 2-4 during toilet training.
- Infrequent after age 6 associated with dysfunctional elimination.
- Neonates with UTI have a high incidence of urinary anomalies.

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Urinary Tract Infection - Imaging

- Ultrasonography
  - noninvasive, avoids radiation, readily available
  - hydronephrosis, duplex renal system, ureterocele
  - post-void bladder volume
- Renal cortical scintigraphy
  - DMSA
  - pyelonephritis, renal scarring
- VCUG
  - vesicoureteral reflux, anatomic abnormalities of urethra and bladder

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Age < 2 months 1st febrile UTI

- Increased incidence of sepsis and renal anomalies associated with UTI.
- Hydronephrosis is most frequent abnormality.
- Newborn males may have VUR even if US is normal.
- Recommendation:
  - Ultrasound
  - VCUG in boys or if sonographic abnormalities

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Age > 2 months and < 6 years 1st febrile UTI with good response

- Ultrasound may detect underlying congenital renal anomalies.
- Routine VCUG exposes children that will not benefit from prophylactic abx to an unpleasant study and radiation.
- Recommendation: US is the only imaging usually appropriate.

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Age > 6 years 1st febrile UTI with good response

- Incidence is infrequent.
- Often associated with behavioral abnormalities, dysfunctional elimination syndrome, or initiation of sexual activity.
- Likelihood of detecting unknown underlying renal anomalies is low.
- Recommendation: No evidence to support any routine imaging. US may be appropriate but is controversial.

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Atypical or recurrent febrile UTI

- US can detect underlying abnormalities, stones, renal abscess.
- Prevalence of VUR increases in children with recurrent UTIs.
- Recommendation: Imaging with VCUG and US to help select children who may benefit from prophylactic abx or antireflux intervention.

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Vomiting in Infants Up To 3 Months

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Vomiting in Infants Up To 3 Months

- Gastroesophageal reflux is normal in the first 3 months of life and resolves in time.
- Usually has no definitive pathologic cause and is unrelated to a functional defect.
- Bilious emesis or repeated forceful vomiting should be evaluated for underlying pathologies.

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Bilious Vomiting

- Usually due to sepsis or obstruction.
- Requires urgent diagnosis and treatment because midgut volvulus about the SMA may lead to small bowel ischemia and necrosis.
- Upper vs. lower GI obstruction.
- Recommendation:
  - In imaging a child with bilious vomiting with possible malrotation, UGI series should be the exam of choice.
  - If abdominal radiograph suggests a distal obstruction, water-soluble contrast enema should be considered.

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Intermittent Nonbilious Vomiting Since Birth

- Common causes
  - idiopathic GER
  - hypertrophic pyloric stenosis
  - overfeeding
  - pylorospasm
  - milk allergy
- Most children with GER who are otherwise healthy do not need any diagnostic workup.
- Extended pH probe is gold standard.
- UGI is insensitive in detecting reflux, but can exclude anatomic abnormalities.
- Recommendation: Imaging evaluation depends on clinical scenario and not always necessary. UGI is preferred when anatomy evaluation is indicated.

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New Onset Nonbilious Vomiting

- Common causes
  - GER
  - hypertrophic pyloric stenosis
  - viral gastroenteritis
  - pylorospasm
- Most children with GER who are otherwise healthy do not need any diagnostic workup.
- Extended pH probe is gold standard.
- UGI is insensitive in detecting reflux, but can exclude anatomic abnormalities.
- Recommendation: US is first imaging consideration for diagnosis of HPS in infant younger than 3 months with projectile nonbilious vomiting.

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Other Scenarios ACR Appropriateness Criteria

- Back pain
- Fever of unknown origin
- Headache
- Hematuria
- Scoliosis
- Seizures
- Sinusitis
- Suspected appendicitis, physical abuse, and spine trauma

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Patient Friendly Appropriateness Criteria

Patient-Friendly Summary of the ACR Appropriateness Criteria: Trauma Head Child

Celena Romero, RD, MBA, CPHQ, Ryan Lee, MD, MBA, MRMD

Head injuries in children can be dangerous and should be evaluated by a doctor. The Glasgow Coma Scale test helps determine if imaging tests are needed. In children with Glasgow scores greater than or equal to 13 with no symptoms of an injury, imaging is often not needed. If the test is less than 14, a computed tomography (CT) scan without contrast is recommended. A CT scan helps identify bleeding, brain tissue damage, fluid in the brain, or skull fractures. The main risk to a child having a CT scan is exposure to radiation.

MRI does not use radiation and is better at finding areas of traumatic damage in the brain than a CT test. MRIs need the child to stay still for a long time, so the doctor may give the child calming medication. MRI is often used to follow up if the symptoms do not go away or if there are new symptoms.

A CT scan of the head is the preferred test when child abuse is suspected. An MRI can be done if the CT scan does not show anything. MRI is better than a CT scan at evaluating areas of brain injury that are more likely in child abuse. An MRI of the top of the spine should also be considered in these cases because there is often damage in this area as well. See the full appropriateness criteria for this topic at https://acsearch.acr.org/docs/3083021/Narrative.

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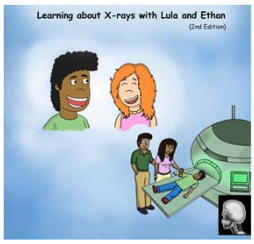
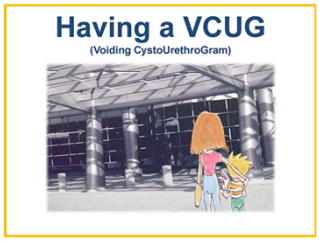
RadiologyInfo.org for kids





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Miscellaneous Pearls

- Help me help you – where does it hurt?
- Head deformity/craniosynostosis – no role for ultrasound.
- At least 2 orthogonal views for XR.
- Comparison views of opposite side not routinely needed.

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Miscellaneous Pearls

- Ordering diagnosis should be sign or symptom – no "rule outs."
- Abdominal trauma – not ruled out with US.
- Limit "2 for 1" deals.
- 2-5 year olds may not drink barium.

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