Evidence-Based Imaging: Getting the Right Study for Your Patient

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Learning Objectives

At the end of this presentation, learners will be able to

- Discuss the ALARA principle and principles of evidence-based imaging and how they relate to radiation safety and best practices

- Locate and use the American College of Radiology (ACR) Appropriateness Criteria®--to your patient’s advantage

Learning Objectives

• Evaluate when an imaging study is indicated and when none is needed

• When indicated, choose the most appropriate study for the workup of
  - Vomiting in an infant up to 3 months of age
  - Suspected malrotation/midgut volvulus
Learning Objectives

• Distinguish among modified barium swallow (MBS), contrast swallow, e.g., barium swallow, upper GI series (UGI), and small bowel follow-through (SBFT)

• Indicate when barium should be used and when water-soluble contrast is needed

Learning Objectives

• When indicated, choose the most appropriate study for the work-up of

  - Head trauma (which may or may not be accidental)

  - Suspected nonaccidental trauma (NAT)
Learning Objectives

• Identify fractures that are common in (NAT)

• When indicated, choose the most appropriate study for the work-up of the limping child, ages 0-5 years

• Restate a useful mnemonic for classifying a common type of pediatric-specific fracture

The ALARA Principle

• **ALARA**

• **As Low As Reasonably Achievable**
The ALARA Principle

• AS LOW AS REASONABLY ACHIEVABLE: Exactly where we need to keep ionizing radiation exposure in children

• What’s “REASONABLY ACHIEVABLE?”

“Reasonably Achievable”

• Sometimes a study with no ionizing radiation will answer your clinical question
  -Ultrasound
  -MRI

• Sometimes no imaging examination is needed
IMAGE GENTLY® Campaign

• Launched in January 2008 by Society for Pediatric Radiology (SPR)

• *Pledge taken by tens of thousands of medical professionals*

• CT protocols can be downloaded free of charge

http://www.imagegently.org/

If you wish, you can go online and take the Image Gently® pledge
Imaging Modalities
CT, Fluoro, MRI, US, X-rays (Radiographs)

• Let’s review which imaging modalities use ionizing radiation and which do not

Imaging Modalities and Ionizing Radiation

YES
• CT
• Fluoroscopy
• Nuclear medicine
• X-rays (radiographs)

NO
• MRI
• Ultrasound
RADIATION SAFETY

• *NOT* having a physics lecture today

Ionizing Radiation

• Absorbed dose (mGy)

• Effective dose (mSv)
Ionizing Radiation

• Background radiation
  3 mSv/yr (millisieverts per year)
  67% from Radon exposure

• Occupational exposure
  20-50 mSv/yr
  Above background exposure

Ionizing Radiation
What’s the big deal?

• Theoretical cancer risk

• Based on *cumulative dose*
Ionizing Radiation Exposure and Cancer

Several studies show association between risk of cancer and increased use of CT scans\(^2\)

<table>
<thead>
<tr>
<th></th>
<th>Head</th>
<th>Chest</th>
<th>Abd/Pelvis</th>
<th>Total</th>
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<tbody>
<tr>
<td>Dose (mSv)</td>
<td>1.1-3.5</td>
<td>5.3-7.5</td>
<td>5.8-8.8</td>
<td></td>
</tr>
<tr>
<td>Projected Cancers</td>
<td>1210</td>
<td>2930</td>
<td>350</td>
<td>4490</td>
</tr>
<tr>
<td>Decrease # scans by 33%</td>
<td>810</td>
<td>1950</td>
<td>260</td>
<td>3020</td>
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<tr>
<td>Decrease dose from 75%ile to median</td>
<td>630</td>
<td>1730</td>
<td>210</td>
<td>2570</td>
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</table>

Ionizing Radiation Exposure and Cancer

Association ≠ Causality
Evidence-Based Imaging (EBI)

• The right thing to do

• Pediatric radiologists know how to do it and are happy to help anyone who wants to learn more

• Together, we can do this!

Evidence-Based Imaging (EBI)

• Sounds good (but we need to define it)
Evidence-Based Imaging (EBI)

clinical information
+ 
physician’s/clinician’s experience
+ 
patient’s/parent’s/caregiver’s expectations
+ 
best available evidence
↓
most appropriate imaging study
Pediatric Evidence-Based Imaging

• The American College of Radiology (ACR) Appropriateness Criteria®

• Quality initiative

• Decision support tool to help you order the right imaging study, the first time

ACR Appropriateness Criteria®

• For a given clinical scenario, e.g., vomiting in infants up to 3 months of age, the ACR rates the appropriateness of an imaging study and stratifies it with regard to radiation dose
ACR Appropriateness Criteria®
Appropriateness Rating Scale

1, 2, and 3: Usually not appropriate

4, 5, and 6: May be appropriate

7, 8, and 9: Usually appropriate

The American College of Radiology (ACR) Appropriateness Criteria®
Radiation Dose

0

☢️
☢️☢️
☢️☢️☢️
☢️☢️☢️☢️
ACR Appropriateness Criteria®

• No cost data

Imaging Studies
Relative Costs

• $ MRI > CT > US > X-rays (Radiographs)

• What about Fluoroscopy (“Fluoro”)?
  $ CT > Fluoro > X-rays
Imaging Studies
Relative Costs

• And what about Nuclear Medicine?
  - Differences in cost among various Nuclear Medicine examinations can be considerable, e.g.,
  PET scan, $1300
  Bone scan, $375

Cost of Imaging Studies\textsuperscript{1,3}

<table>
<thead>
<tr>
<th></th>
<th>Mean Radiation (mSv)</th>
<th>CXR Equivalents</th>
<th>Charges (US$)</th>
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</thead>
<tbody>
<tr>
<td>CXR</td>
<td>0.05</td>
<td>1</td>
<td>50-300</td>
</tr>
<tr>
<td>KUB/Abdomen</td>
<td>0.7</td>
<td>14</td>
<td>50-350</td>
</tr>
<tr>
<td>Head CT without contrast</td>
<td>1-3</td>
<td>20-60</td>
<td>200-1200</td>
</tr>
<tr>
<td>Chest CT without contrast</td>
<td>5-8</td>
<td>100-160</td>
<td>200-1500</td>
</tr>
<tr>
<td>Abd/Pelvis with contrast</td>
<td>10-15</td>
<td>200-300</td>
<td>500-4500</td>
</tr>
<tr>
<td>DMSA or MAG3</td>
<td>3</td>
<td>60</td>
<td>150-1850</td>
</tr>
<tr>
<td>MRI brain without contrast</td>
<td>0</td>
<td>0</td>
<td>550-2250</td>
</tr>
<tr>
<td>Ultrasound of (insert organ here)</td>
<td>0</td>
<td>0</td>
<td>100-1000</td>
</tr>
</tbody>
</table>

Adapted from References 1 and 3
Costs of Imaging Studies

• Don’t forget hidden and non-monetary costs
  – Sedation
  – Patient and family stress
  – Unintended consequences

LOCATE ACR Appropriateness Criteria®

• Get your device

• Open your browser

• Type “ACR appr” in the search bar
ACR Appropriateness Criteria®

Multiple Sections

- Breast
- Cardiac
- Gastrointestinal
- Musculoskeletal
- Neurologic
- Pediatric
- Thoracic
- Urologic
- Vascular

Interventional Radiology

Radiation Oncology
ACR Appropriateness Criteria® Pediatric Topics

- Back Pain
- Developmental dysplasia of the hip
- Fever without source or Unknown Origin
- Head trauma
- Headache
- Hematuria
ACR Appropriateness Criteria®
Pediatric Topics

- Limping child - age 0 to 5 years
- Seizures
- Sinusitis
- Suspected physical abuse
- Urinary tract infection
- Vomiting in infants up to 3 months of age

ACR Appropriateness Criteria®

- Phone app from my personal phone
BEST PRACTICES

• ALARA Principle

• Safety-prioritized

• Patient-centered/Relationship-centered

• Quality-focused
BEST PRACTICES

- Don’t order unnecessary studies, especially if they use ionizing radiation
- Babygram ordered when you actually need chest x-ray or abdominal x-ray but not both
- BOTTOM LINE: Avoid ordering imaging of anatomy that does not need to be evaluated

BEST PRACTICES
REDUCING EXPOSURE: GONADAL SHIELDS

- Ask your radiologists if they using gonadal shields in every examination for which they are appropriate
BEST PRACTICES
REDUCING EXPOSURE: “CONING OUT”/COLLIMATION

• Check to see if appropriate collimation is used in studies at your institution
• For example, pelvis is “coned out” if you don’t need to see it

HISTORY: We need it!
Least Favorite ICD-10 Entity

“Other injury, unspecified body part”*

*We don’t know what happened.
We don’t know where it happened.
We just know something happened.

Clinical Scenarios

Let’s start with the vomiting infant!
Vomiting Infant

- Vomiting vs. regurgitation
- Bilious vs. bloody vs. neither
- Solid H&P will yield the path to take

CASE 1
4-day-old infant with vomiting

- Benign prenatal course
- Spontaneous vaginal delivery at 40 weeks, discharged to home, breastfeeding at 48 hours
- As you’re examining the child, he has an episode of bright green emesis all over you!
4-day-old infant with bilious vomiting

• Do you need imaging? Yes!

• What’s your strategy?

VOMITING
Choice of Imaging Studies

• Abdominal x-rays
• Abdominal ultrasound
• Upper GI series
• Contrast enema
• Contrast swallow
• Modified Barium Swallow
• CT
• MRI
VOMITING
Choice of Imaging Studies

• Abdominal x-rays
• Abdominal ultrasound
• Upper GI series
• Contrast enema
• Contrast-swallow
• Modified Barium-Swallow
• CT
• MRI

ACR Appropriateness Criteria®
Vomiting in an infant up to 3 months of age

4 Variants
ACR (American College of Radiology)
Appropriateness Criteria®

American College of Radiology        Date of origin: 1995
ACR Appropriateness Criteria®        Last review date: 201
Clinical Condition: Vomiting in Infants Up to 3 Months of Age

Variant 1: Bilious vomiting in neonate up to 1 week old

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray abdomen</td>
<td>9</td>
<td>Initial x-ray will help determine further workup strategy.</td>
<td>⚠️⚠️</td>
</tr>
<tr>
<td>X-ray upper GI series</td>
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<td></td>
<td>⚠️⚠️</td>
</tr>
<tr>
<td>X-ray contrast enema</td>
<td>7</td>
<td></td>
<td>⚠️⚠️⚠️</td>
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<tr>
<td>US abdomen (UGI tract)</td>
<td>4</td>
<td></td>
<td>0</td>
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</table>

Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

Bilious emesis in neonate up to 1-week-old

9 Abdominal x-ray

- X-ray is important
  - Evaluate for obstruction,
  - proximal vs. distal
  - Look for free air

8 Upper GI series

7 Contrast enema

4 Abdominal ultrasound
ACR (American College of Radiology) Appropriateness Criteria®

Clinical Condition: Vomiting in Infants Up to 3 Months of Age

Variant 2: Bilious vomiting in infant 1 week to 3 months old

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray upper GI series</td>
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<td>☢☢☢</td>
</tr>
<tr>
<td>X-ray abdomen</td>
<td>5</td>
<td></td>
<td>☢☢</td>
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<tr>
<td>US abdomen (UGI tract)</td>
<td>3</td>
<td></td>
<td>0</td>
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<tr>
<td>Tc-99m sulfur colloid reflux scintigraphy</td>
<td>1</td>
<td></td>
<td>☢☢☢</td>
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</table>

Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

Bilious emesis in infant 1 wk to 3 mo old

9 Upper GI series
5 Abdominal x-ray
3 Abdominal ultrasound
1 Nuclear medicine sulfur colloid reflux scintigraphy
ACR (American College of Radiology) Appropriateness Criteria®

Clinical Condition: Vomiting in Infants Up to 3 Months of Age

Variant 3: Intermittent nonbilious vomiting since birth

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
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<tbody>
<tr>
<td>X-ray upper GI series</td>
<td>6</td>
<td>☢☢☢</td>
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<tr>
<td>US abdomen (UGI tract)</td>
<td>4</td>
<td>☢☢</td>
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<tr>
<td>Tc-99m sulfur colloid reflux scintigraphy</td>
<td>3</td>
<td>May seldom provided useful information about gastric emptying and GER</td>
</tr>
<tr>
<td>X-ray abdomen</td>
<td>1</td>
<td>☢☢</td>
</tr>
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</table>

Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

*Relative Radiation Level

Intermittent nonbilious vomiting since birth
“The Spitter”

6 Upper GI series

4 Abdominal ultrasound

3 Nuclear medicine gastric emptying study

1 Abdominal x-ray

Adapted from Reference 8
ACR (American College of Radiology) Appropriateness Criteria®

Clinical Condition: Vomiting in Infants Up to 3 Months of Age

Variant 4: New-onset projectile nonbilious vomiting

<table>
<thead>
<tr>
<th>Radiologic Procedure</th>
<th>Rating</th>
<th>Comments</th>
<th>RRL*</th>
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</thead>
<tbody>
<tr>
<td>US abdomen (UGI tract)</td>
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<td></td>
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<tr>
<td>X-ray upper GI series</td>
<td>6</td>
<td></td>
<td>☢☢</td>
</tr>
<tr>
<td>X-ray abdomen</td>
<td>2</td>
<td></td>
<td>☢</td>
</tr>
<tr>
<td>Tc-99m sulfur colloid reflux scintigraphy</td>
<td>1</td>
<td></td>
<td>☢☢☢</td>
</tr>
</tbody>
</table>

Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

New-onset projectile nonbilious vomiting

9 Abdominal (pyloric) ultrasound

6 Upper GI series

2 Abdominal ultrasound

1 Nuclear medicine sulfur colloid reflux scintigraphy
Tables are followed by evidence

- Expert Panel on Pediatric Imaging: Dorothy Bulas, MD1; Siobhán L. McGrane, MD2; Brian D. Coley, MD3; Boaz Karmazyn, MD4; Lori L. Barr, MD5; Larry A. Binkovitz, MD6; Christopher E. Dory, MD7; Matthew Garber, MD8; Laura L. Hayes, MD9; Marc S. Keller, MD10; Abhaya V. Kulkarni, MD11; James S. Meyer, MD12; Sarah S. Milla, MD13; John S. Myseros, MD14; Charles Paidas, MD15

- Summary of Literature Review

- Introduction/Background

- Vomiting, or the forceful extrusion of gastric contents, is never normal in the neonate and usually occurs because of complete or partial obstruction somewhere along the course of the gastrointestinal (GI) tract between the stomach and cecum [1]. However, there may be difficulty in differentiating clinically between vomiting and regurgitation.
Oropharynx and Esophagus
Common Clinical Concerns

• Difficulty swallowing
• Gagging
• Coughing
• ? Aspiration
• Odynophagia
• ? Esophageal stricture
• ? Esophageal perforation/tear

Fluoroscopy ("Fluoro") studies

• Modified barium swallow
• Contrast swallow
  - Barium
  - Water-soluble contrast
• Upper GI (UGI) series
• Small bowel follow-through (SBFT)
• Contrast enema (barium or water-soluble contrast)
Fluoroscopy Studies
Which one to choose?

• Let’s proceed in logical anatomic fashion

• Start with studies that evaluate more proximal problems and proceed to studies that evaluate more distally

Modified Barium Swallow

• Performed in conjunction with our colleagues in Speech Pathology
  - Primarily video (few, if any, static images)
• Focuses on mechanics of swallowing
• Best test to evaluate for aspiration!
Modified Barium Swallow (MBS)

• Does not evaluate for gastroesophageal (GE) reflux

• May not be able to be done immediately before or after upper GI series

• Why? Depends on requesting clinician’s priorities

What does that mean?

• If your primary concern is the mechanics of swallowing and/or aspiration, then Modified Barium Swallow is the 1st test that should be done
What about concern for malrotation?

• If you’re more concerned about the possibility of malrotation and midgut volvulus than aspiration, then UGI series should be done prior to Modified Barium Swallow

Contrast Swallow

• If need to evaluate ESOPHAGUS for ulcer, perforation, or tear:  *Not* modified barium swallow—you’re *not* primarily interested in swallowing mechanics and/or evaluating for aspiration
• You need a CONTRAST SWALLOW
Contrast Swallow
Mouth to gastric fundus *only*

- Which contrast?
  - Barium?
  - Water-soluble contrast?

- And if water-soluble contrast, which one?
Contrast Swallow
Mouth to gastric fundus only

• Best test if need to evaluate esophagus only, e.g., if concern for esophageal tear

• NO BARIUM if concern for PERFORATION/LEAK

• Use water-soluble contrast if possibility of perforation/leak; same is true for abdomen

Water-Soluble Contrast

• For pediatric patients, NO high-osmolality water-soluble contrast, either orally or by NG/OG tube or G-tube

• NO EXCEPTIONS
Contrast Swallow
Water-soluble contrast

• Low-osmolality water-soluble contrast only

NO High-Osmolality Water-Soluble Contrast

• Why not?

• If aspirated, high-osmolality contrast can cause flash pulmonary edema
Contrast Swallow
Barium or Water-soluble Contrast

• Does NOT evaluate well for GE REFLUX

• Only evaluates from mouth to gastric fundus, not entire stomach

If concern for abnormality involving

- Esophagus and Stomach
- Stomach only
- Stomach and Duodenum
- Duodenum only

• UGI series is the best choice for your patient because it evaluates
  - Esophagus
  - Stomach
  - Duodenum (YES, DUODENUM is included)
Duodenum

• You DO NOT need a small bowel follow-through (SBFT) to evaluate the duodenum

• Get an UGI series

UGI Series
From mouth to ligament of Treitz/duodenojejunal junction
Upper GI Series

• Patient should be NPO!

Upper GI Series
Patient has an NG tube
UGI Series

To exclude malrotation, must establish normal position of ligament of Treitz

- Contrast must progress through duodenum
  - To left of spine’s left pedicles
  - Up to level of duodenal bulb
- Not either/or, it’s both/and
- If not both/and, we have to call malrotation
Evaluate for Malrotation and Midgut Volvulus

• Best test: UGI series

Upper GI Series
Upper GI Series

- Radiologist called malrotation, no midgut volvulus

- Surgeons asked radiologist to *repeat* UGI Series

- WHY?
Repeat UGI Series

Repeat UGI Series
Repeat UGI Series

- **No** malrotation
- What was wrong with the 1st UGI series?

Upper GI Series (UGI)

*First 2 Images, what’s the problem?*
• Stomach is *massively* gas-distended
• Difficult to determine rotation in this setting
  - Stomach is exerting mass effect on duodenum
  - *May* prevent contrast from passing to left of left pedicles and up to level of bulb
  - Malrotation *may or may not* be present
UGI Series

- In this case, on repeat UGI series, there was no evidence of malrotation.

- Take-home point: Markedly distended stomach may contribute to appearance of malrotation when it is not present.

- May need to drop NG/OG tube prior to UGI.

Abdominal Pain
Chronic Recurrent Abdominal Pain

Abdominal Pain in Another Patient
Next Patient, Also Abdominal Pain

Jejunum and Ileum

• Small bowel follow-through (SBFT)
  -Includes the terminal ileum (TI)

• MR Enterography (MRE)
Colon and Rectum

- Contrast enema
  - Barium
  - Water-soluble contrast
- CT colonography
- MRI

Summary of Fluoroscopy Studies
From Proximal to Distal

- MBS: Mechanics of swallow, evaluates for aspiration
- Contrast swallow: Mouth to gastric fundus (does not evaluate well for GE reflux)
- UGI series: Mouth to duodenojejunal junction/ligament of Treitz, includes duodenum
- SBFT: Entire small bowel, including terminal ileum (usually see proximal colon)
- Contrast enema: Rectum and colon (usually reflux contrast into distal small bowel)
Evaluate for Intussusception

• Evaluation *should begin* with abdominal x-rays
• *No agreement on utility of* x-ray*, except for excluding free air*
• *Most* children with intussusception have *abnormal* abdominal x-rays

Intussusception: Diagnosis
In addition to x-rays, WHAT ELSE?

• ULTRASOUND!
Intussusception: Diagnosis
WHY ULTRASOUND?

- Sensitivity: 95-100%
  *In hands that are experienced, sensitivity of ultrasound is essentially 100%*
- Specificity: 88-100%
- False positives
  - Fecal content
  - Inflammatory bowel disease
  - Intramural hematoma
Intussusception

free fluid

RLQ Trans S-I

Intussusception

free fluid

RUQ

RUQ
Intussusception

Fluid within the intussusception

Intussuscepted bowel contains blood flow
Intussusception

Intussuscepted bowel contains blood flow

Intussusception

Intussuscepted bowel, no internal blood flow
CASE 2
Head trauma

You are helping staff your Community Hospital Emergency Department when EMS calls and says they are coming to your facility with an 18-month-old boy who wandered into the street and was struck by a car.

• Cervical spine precautions have been taken and they say they have been unable to awaken him with a sternal rub.
• When the child arrives he now has open eyes but is not interactive with his mother
• Should this child get a head CT?
• What if he was hit by a car but never had altered mental status?
• What if he was 8 years old and not 18 months?

PECARN Head Trauma Prediction Rules

<2 years old

• GCS <15, skull fracture palpated, altered mental status
  CT head without contrast (TBI≈4.4%)
• Scalp hematoma anywhere but frontal, loss of consciousness for more than 5 seconds, parents state abnormal behavior or severe mechanism of injury
  (fall >3 ft, motor vehicle collision with ejection, rollover or fatality, pedestrian or bicycle against a vehicle without a helmet or hit in the head with a high impact object
  CT head without contrast versus observation (TBI≈0.9%)
• No to all means observation
  (TBI<0.02%)

Adapted from Reference 7
PECARN Head Trauma Prediction Rules

2 years and older

• GCS <15, signs of basilar skull fracture, altered mental status
  CT head without contrast (TBI≈4.3%)
• Vomiting, LOC, severe headache, severe mechanism of injury
  -(fall >5 ft, motor vehicle collision with ejection, rollover or fatality, pedestrian
  or bicycle against a vehicle without a helmet or hit in the head with a high
  impact object
  CT head without contrast versus observation (TBI≈0.8%)
• No to all means observation
  (TBI<0.05%)

Adapted from Reference 7

ACR Appropriateness Criteria®

Head Trauma

• Clinical Condition: Head Trauma — Child
• Variant 1: Minor head injury (GCS >13) ≥2 years of age, without neurologic signs or high-risk factors, e.g., altered mental status, clinical evidence of basilar skull fracture. Excluding nonaccidental trauma.

3 CT head without IV contrast. This is a known low-yield procedure
2 MRI head without IV contrast
1 All 11 studies: X-ray head, CT head without and with IV contrast, CT head with IV contrast, CTA head with IV contrast, MRI head without and with IV contrast, MRA head without IV contrast, MRA head without and with IV contrast, cerebral arteriography, head ultrasound, FDG-PET/CT head, and Tc-99m HMPAO SPECT head
ACR Appropriateness Criteria®
Head Trauma

• Clinical Condition: Head Trauma — Child
• Variant 2: Minor head injury (GCS >13) <2 years of age, no neurologic signs or high-risk factors, e.g., altered mental status, clinical evidence of basilar skull fracture. Excluding nonaccidental trauma.

3 X-ray head. Refer to variant 4 if concern for nonaccidental trauma
3 CT head without IV contrast
3 MRI head without IV contrast [Low yield in absence of signs of symptoms]
2 MRA head without IV contrast
2 CTA head with IV contrast
1 All 6 studies: MRI head without and with IV contrast, MRA head without and with IV contrast, cerebral arteriography, head ultrasound, FDG-PET/CT head, and Tc-99m HMPAO SPECT head

ACR Appropriateness Criteria®
Head Trauma

• Clinical Condition: Head Trauma — Child
• Variant 3: Moderate or severe head injury (GCS <13) or minor head trauma with high-risk factors, e.g., altered mental status, clinical evidence of basilar skull fracture. Excluding nonaccidental trauma.

9 CT head without IV contrast
7 MRI head without IV contrast
4 MRA head without IV contrast. Consider if vascular injury is suspected.
4 CTA head with IV contrast. MRA is preferred. CTA may be used for problem-solving.
3 MRA head without and with IV contrast
2 All 5 studies: X-ray head, CT head without and with IV contrast, CT head with IV contrast, MRI head without and with IV contrast, and cerebral arteriography
1 All 3 studies: Head ultrasound, FDG-PET/CT head, and Tc-99m HMPAO SPECT head
ACR Appropriateness Criteria®
Head Trauma

• Clinical Condition: Head Trauma — Child
• Variant 4: Suspected nonaccidental trauma
  9 CT head without IV contrast
  8 MRI head without IV contrast
  7 X-ray head
  3 MRA head without IV contrast. Consider if vascular injury is suspected. May be performed in conjunction with neck imaging.
  3 Head ultrasound
  2 All 4 studies: MRI head without and with IV contrast, MRA head without and with IV contrast, CT head without and with IV contrast, and CT head with IV contrast
  1 All 4 studies: Cerebral arteriography, CTA head with IV contrast (MRA is preferred to CTA but CTA may be used for problem-solving), FDG-PET/CT head, and Tc-99m HMPAO SPECT head

ACR Appropriateness Criteria®
Head Trauma

• Clinical Condition: Head Trauma — Child
• Variant 5: Subacute head injury with cognitive and/or neurologic signs
  8 MRI head without IV contrast. MRI is preferred, but imaging should not be delayed if it is not readily available
  7 CT head without IV contrast
  3 MRA head without IV contrast. Consider if vascular injury is suspected.
  2 All 5 studies: MRI head without and with IV contrast (not indicated unless there is concern for infection), MRA head without and with IV contrast, CT head without and with IV contrast, CTA head with IV contrast, and cerebral arteriography
  1 All 5 studies: X-ray head, CT head with IV contrast, head ultrasound, FDG-PET/CT head, and Tc-99m HMPAO SPECT head
CASE 3

11-week-old with nonbilious vomiting and fussiness

WHAT DO YOU SEE?

How does the bowel gas pattern look?

Normal or not?

What else should we look at?