Challenges of Imaging Pediatric Abdominal Emergencies

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Challenges of Imaging Children

- History and physical exam less reliable
  - Site of pain may be very misleading
- Choosing the best initial modality
  - Organ of interest
  - Age of the patient
    - Differing pathology
    - Patient cooperation
- Safety issues
Learning Objectives

• Understand the variations of pathology that cause abdominal pain and vomiting in infants and children
• Plan safe and effective imaging protocols using US, CT, and MRI
• Recognize pitfalls in the diagnosis of pediatric abdominal emergencies with imaging

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What percentage of patients in your practice are < 15 years of age?

- 80 - 100%
- 50 – 79%
- 25 – 49%
- 5 – 25%
- < 5%
Abdominal Pain in Infants and Children

- History and physical findings overlap
  - Diarrhea
  - Blood in stool
  - Episodic crying
  - Poorly localized pain

- Pathologies cluster in specific age groups
  - Newborn
  - 1 week – 2 months
  - 2 - 5 months
  - 5 months – 2 years
  - 2 yrs - adolescence
1 to 8 Weeks of Age

- Gastroesophageal reflux
- Gastric outlet obstruction
  - Pyloric muscle
    - Spasm
    - Hypertrophy
Hypertrophic Pyloric Stenosis

- Infants 3-6 weeks of age
  - Younger patients increasing
- Projectile vomiting
  - Non-specific
- US is best modality
  - 7-12 mHz transducer
  - Fluid-filled stomach
Normal Pylorus

- 1-2 mm muscle
- Length negligible
- Opens frequently
Hypertrophic Pyloric Stenosis

- 3 mm + muscle
- 1.5 cm + length
- Little or no emptying
Pitfall – the empty stomach!

- Administer fluid (sugar water), if needed
- Oblique patient to right
Congenital/Developmental Abnormalities

- Incomplete duodenal obstruction
  - Diaphragm
  - Stenosis
- Acute duodenal obstruction
  - Midgut volvulus
- Colon obstruction
  - Hirschprung disease
3 month old with increasing vomiting
Duodenal Web

Early incomplete obstruction can progress to complete obstruction later
Duodenal Web

- Incomplete obstructing band
- Second portion of duodenum
7 week old with vomiting

Annular Pancreas
17 year old with new onset abdominal pain with meals

Annular Pancreas
Midgut Volvulus

- Acute obstruction
- Minimal findings on radiographs
- Contrast exams versus US
SMV normally lies to the right of SMA

Obstruction 3rd portion of duodenum = midgut volvulus
1 week old with vomiting

Recurrent vomiting 2 wks s/p Ladd’s procedure

Midgut Volvulus
Abdominal Heterotaxy and Volvulus

- High incidence of malrotation in children with abdominal heterotaxy
Duodenojejunal junction and cecum on same side of abdomen may indicate risk.
Duodenal obstruction in infants and children:

1) Cannot be evaluated with US.
2) Always requires emergent surgery.
3) Requires emergent surgery when complete obstruction occurs in the 2nd portion of the duodenum.
4) Requires emergent surgery when complete obstruction occurs in 3rd portion of duodenum.
5 months to 2 years

- Ileocolic intussusception
  - Episodes of crying
  - Vomiting
  - Drawing up legs
  - Lethargy
  - Bloody (current jelly) stools
  - Palpable abdominal mass
Intussusception

- Causes
  - Lead points
    - Meckel’s diverticulum
    - Polyps
    - Intestinal duplication cyst
  - Lymphoma
  - Henoch-Schoenlein purpura
  - Post-operative
- Most are idiopathic
  - Gastroenteritis/hyperperistalsis
- Consider a lead point if repeated recurrences or age over 4 years
Radiographs

- May be suggestive but often non-specific
  - Mass effect along course of colon
  - Target sign
  - Small bowel obstruction
Ultrasound for Intussusception

- High frequency (7-12 mHz) transducer
- Complex mass
  - Target, donut appearance
- High sensitivity and specificity
- If US negative, contrast enema not needed

Lack of flow with Doppler suggests ischemia, but not a contraindication to non-surgical reduction
Transient Intussusception

- Common in patients with hyperperistalsis
Non-surgical Reduction

- Few contraindications
  - Peritoneal signs
  - Free air on radiographs
- Free fluid not a contraindication
- Enema reduction
  - Hydrostatic
    - Fluoroscopy vs. US
  - Air
Air Enema Reduction

• Advantages
  – Faster (less radiation)
  – Less messy
  – Higher reduction rate
  – Smaller hole and less contamination with perforation
Can be more difficult to identify residual ileo-ileal intussusception
Perforation

- Keep below 120 mm Hg to avoid perforation
- Keep 21 g spinal needle handy, in case acute decompression is needed
2 yrs old and greater

- Inflammatory conditions predominate
  - Appendicitis
  - Mesenteric adenitis
  - Ileocolitis/gastroenteritis
  - Henoch-Schoenlein purpura
  - Hemolytic uremic syndrome
  - Regional enteritis
In my practice, the initial imaging study performed on children with suspected appendicitis is:

1) Abdomen radiographs
2) Complete abdomen US
3) Right lower quadrant US
4) Contrast-enhanced abdomen US
5) Abdomen/pelvis CT without contrast
6) Abdomen/pelvis CT with contrast
US for Appendicitis

- Still accepted as best first screening exam
- Staged approach using CT for equivocal cases highly accurate
  - Sensitivity 98.6%  
  - Specificity 90.6%  
  - CT avoided in 53%

Krishnamoorthi, Radiol Jan. 2011
Appendix Size in Appendicitis

- **6 mm or > in diameter**
  - PPV – 63%
  - NPV – 100%
  - More useful for excluding appendicitis
  
  Rettenbacher, Radiology 2011; 218: 757.

- **7 mm or >**
  - Similar accuracy
  
Compressibility – can be difficult to demonstrate with normal appendix.

Normal

Appendicitis
Lymphoid Hyperplasia of the Appendix

- Enlarged lymphoid tissue in the wall of appendix
  - Response to viral infection
- Can mimic a fluid-filled appendix
  - Look for central mucosal stripe
- May result in increased size
Perforated Appendix

- Dilated small bowel
- RLQ mass
- Colon cut-off
- Flank stripe
Signs of Active or Impending Perforation

- Loss of mucosal lining
- Edematous fat
- Adjacent fluid collections

Secondary findings can be strong indicators of appendicitis

Thickened Echogenic Fat = Inflammation

Complex free fluid = peritonitis
Abscesses Mimic Other Pathologies

Hematometrocolpos

Abscess from perforated appendicitis
Appendiceal Abscess
Abdominal/Pelvic CT in Children

- IV contrast – 2cc/kg
- Oral or rectal contrast often not needed
  - Oral water may be a good alternative
- Coronal reconstruction
- Take measures to reduce radiation exposure
Advice for Decreasing Dose in Pediatric CT  
Goske et al, AJR (2008)

- “Child-size” your CT (kVp, mA)
  - Pediatric protocols on IG website (www.imagegently.org)
- Scan only when necessary
- Scan only the indicated region
  - Requires point of care protocoling
- Scan only once
  - Delayed imaging not needed for abdominal pain; for trauma scans should be restricted to those cases with high risk injuries on initial pass images
Challenges with CT

- Lack of intra-abdominal fat
Ultrafast 3T MRI for Appendicitis

- 42 children
  - Ages 4-17
- No sedation or contrast
- TSE sequences w/wo fat saturation
- Scan times less than 9 minutes
- Normal appendix seen 43% of the time
- Sens/spec 100/99%
  - PPV 98%
  - NPV 100%

Johnson, AJR 2012, Jun 198:1424
MRI for Pediatric Appendicitis

  - 208 patients, 4-17 years
  - 4 sequences 1.5T (cor T2, axial T2 w/wo fat sat, cor SPAIR)
  - Scan time mean = 14.2 mins
  - Normal appendix seen in 36% of true negative cases
  - Sens/spec 97.6/97.0%
    - PPV 88.9%
    - NPV 99.4%

- Herliczek, AJR, May 2013; 200: 969.
  - 60 patients, 7-17 years
  - Multiple sequences, 1.5 and 3T (T2 TSE, HASTE, STIR, T1, T1 in/out phase)
  - Scan time mean = 30.5 mins
  - Normal appendix seen in 83-88% of cases
  - Sens/spec 100/96
    - PPV 83%
    - NPV 100%
Appendicitis
Calcified appendicolith with distal obstruction
3 yr 11 month old with normal appendix
Normal appendix
Which of the following statements is correct?

1) Appendiceal diameter of 6 mm is a strong positive predictor of appendicitis.
2) Ultrafast MRI for appendicitis can be performed without sedation in children under the age of 6 years.
3) US for pyloric stenosis should be performed after fasting.
4) Air enema reduction of intussusception should not be performed if US shows bowel obstruction and free fluid.
Unexpected Diagnoses

5 yr old with abdominal pain, fever, and vomiting

Left Lower Lobe Pneumonia
4 year old with abdominal pain

3 weeks later
Leukemia with pathologic compression fractures

Young children localize pain poorly; “abdominal pain often reflects pathology in spine, pelvis, or chest
Abdominal Emergencies in Children

- Age appropriate diagnoses
- Multi-modality imaging often needed
  - Use ultrasound whenever possible
  - Lower the dose when using CT
  - Consider MRI when US not diagnostic

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