Acute Abdomen From Infancy to Adolescence - What is your Imaging Choice?

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Disclosure

I have no financial relationships with commercial interests

Cultural & Linguistic Competency

Issues in cultural and linguistic competency will be addressed in this activity.
(e.g. differences in prevalence, diagnosis, treatment in diverse population; linguistic skills; pertinent cultural data etc.)
Question #1: Do you know of the "Image Gently"/IG Campaign?

1. Yes
2. No
3. Maybe
4. Not Sure

OBJECTIVES
1. State Alliance for Radiation Safety - Image Gently & Image Wisely
2. Compare various imaging Studies to formulate the "Best Approach for Acute Abdomen in Children"
3. Illustrate imaging findings of various pathologies of Acute Abdomen from Infancy to Adolescence
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The Image gently Campaign (launched 1/22/08) is an initiative of the Alliance for Radiation Safety in Pediatric Imaging.

Goal is to change practice by increasing awareness of the opportunities to promote radiation protection in the imaging of children.

The Society for Pediatric Radiology as well as over 33 other societies are members of this coalition representing more than 500,000 health care professionals.

21,393 medical professionals have taken the pledge
There is no conclusive evidence that radiation from diagnostic X-rays causes cancer. However, some studies of large populations exposed to radiation have demonstrated slight increases in cancer risk even at low levels of radiation exposure, particularly in children.

To be safe, we should act as if low doses of radiation may cause harm.

The overall risk of a cancer death over a person’s lifetime is estimated to be 20-25%. For every 1,000 children, 200-250 will eventually die of cancer if never exposed to medical radiation.

The estimated increased risk of cancer over a person’s lifetime from a single CT scan is controversial but has been estimated to be a fraction of this risk (0.03-0.05%). But the available research indicates that there may be some risk and the risk may be cumulative.

How can we minimize radiation risk to a child?

1. As Low As Reasonably Achievable (ALARA) principle.

2. Strategies:
   - Image when there is a clear medical benefit
   - Use the lowest amount of radiation for adequate imaging based on size (NOT AGE) of the child
   - Image only the indicated area
   - Avoid multiple scans
   - Use alternative diagnostic studies (such as ultrasound or MRI) when possible
Question # 2: Which study has the most effective radiation dose?

1. CT brain
2. CT chest
3. CT abdomen
4. CT extremity

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Question # 3: The radiation from CT abdomen is equivalent to how many Chest radiographs (CXR)?

1. 20
2. 30
3. 50
4. 100
5. Not sure
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2. 2. 30
3. 3. 50
4. 4. 100
5. 5. Not sure

Radiation source | Days background radiation
--- | ---
Background | 1 day
Airline flight (3hrs) | 1.5 days
Chest X-ray (single) | 1 day
VCUG | 9 days to 6 months
Upper GI | 1 year
Contrast enema | 1.5 years
Head CT | up to 8 months
Abdominal CT | up to 20 months

Source | Estimated effective dose (mSv)
--- | ---
Natural background radiation | 3 mSv/yr
Airline passenger (cross country) | 0.04 mSv
Chest X-ray (single view) | up to 0.01 mSv
Chest X-ray (2 view) | up to 0.1 mSv
Head CT (20 CXR) | up to 2 mSv
Chest CT (30 CXR) | up to 3 mSv
Abdominal CT (50 CXR) | up to 5 mSv
The American College of Radiology (ACR) and the Radiological Society of North America (RSNA) formed the Joint Task Force (JTF) on Adult Radiation Protection to address concerns about the surge of public exposure to ionizing radiation from medical imaging.

The Joint Task Force (JTF) collaborated with the American Association of Physicists in Medicine (AAPM) and the American Society of Radiologic Technologists (ASRT) to create the Image Wisely campaign with the objective of lowering the amount of radiation used in medically necessary imaging studies and eliminating unnecessary procedures.

Image Wisely offers resources and information to radiologists, medical physicists, other imaging practitioners, and patients.
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Introduction

- Most cases of pediatric abdominal pain are self-limiting
  - Constipation, gastroenteritis, viral syndrome
- However, some cases can be serious and may require intervention
  - Appendicitis, bowel obstruction, infections

*Necessary to identify potentially life-threatening conditions*
Approach to Acute Abdomen

- History
- Physical Exam
- Laboratory Studies
- Imaging

Imaging
- US
- Plain Radiography (CXR, Abd)
- CT
- Contrast Studies: UPPER GI study, Small bowel series, Enema, IVP
- MRI
- Nuclear Imaging
- Angiography

Question #4: What is your first imaging choice for suspected appendicitis?

1. Radiograph abdomen (AXR)
2. Ultrasound RLQ
3. CT abdomen and pelvis
4. MRI abdomen
ARS Question # 4: What is your first imaging choice for suspected appendicitis?

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4. MRI abdomen

Imaging versus NO Imaging??

- A recent controversial report by Lee[3] indicated that neither the use of CT nor US led to improved diagnostic accuracy for appendicitis, but, in fact, these procedures actually might delay surgical consultation and necessary appendectomy.

- In a report by Schuler et al[7] the use of CT reduced the negative appendectomy rate from 21% without the use of preoperative CT to 6% with the use of CT. Therefore, most would utilize imaging, either CT or US, in cases in which the diagnosis of appendicitis is equivocal.

Ultrasound

- NO radiation, quick and easily done
- Available 24/7/365 @ OVMC with STAT reads
- Acute appendicitis
  - Specificity = 96%, sensitivity = 86%
  - Franke et al., World J Surg, 1999
- Genitourinary Conditions
  - Ovarian torsion, ruptured ovarian cyst, and testicular torsion
- Best diagnostic test for intussusception
- Inflammatory/Infectious Processes
US evaluation ONLY???

- Dilley et al.[18] Dedicated radiologists available 24 hours a day to perform appendiceal US had a sensitivity of 89%, a specificity of 95%.

- Baldisserotto et al.[20] Using their technique, they reported US had a sensitivity of 98.5%, a specificity of 98.2%.

Advantages and disadvantages of various CT techniques.

- No IV contrast: Quick, Best with larger patient
- IV contrast: Better identification of the appendix and other pathology
- Focused exam: Limit radiation dose (abdomen and pelvis)
- Complete examination of abdomen/pelvis: Identify unusual location of appendix and other pathological conditions
- Oral contrast: Opacify bowel, ileum and appendix
- Rectal contrast: Opacify cecum and appendix
- Trained personnel required***

ORAL AND IV: preferred***

CT versus US versus Clinical Evaluation?

- 1994, Balthazar et al.[8] published data showing US sensitivity of 76% and CT sensitivity of 96% with US accuracy of 83% compared with the CT accuracy of 94%.

- Similar comparative sensitivities have been reported with spiral CT compared with compression US, with CT sensitivity ranging from 85% to 100% and US sensitivity ranging from 74% to 100%.[9-11]

- In most studies, use of both CT and US led to a decrease in the negative appendectomy rate compared with clinical evaluation.[10]

CT versus US?

- US
  ALWAYS FIRST
  Always FIRST and INITIAL evaluation...may be also a repeat evaluation if needed
- CT
  Always after US and FOR further evaluation
  Complicated cases/unusual presentation

Plain Radiography

- Chest radiograph (CXR):
  - Essential in all cases of an acute abdomen (however not always done!)
  - Preoperative assessment
  - R/O supra-diaphragmatic conditions that simulate an acute abdomen (e.g. lower lobe PNA)

Plain Radiography (AXR)

- Radiograph Abdomen:
  - SBO***
  - Mass
  - Organomegaly
  - Free air
  - Abnormal Calcifications
Radiograph Abdomen (AXR)

2 view study:
1. Frontal supine view
2. Free air view
   - Upright view
   - Left Lateral decubitus
   - Cross table lateral (NICU)

EXCEPTION to 2 view rule
1. Rule out constipation

GI Contrast Studies

Use:
- Not to be used for screening
- Water-soluble contrast medium (Gastrografin)
  Can be diagnostic and therapeutic - reduction of intussusception
  Suspected perforations of esophagus/gastro-duodenal area
- Barium
  - No clinical evidence of bowel perforation
  - Barium small bowel follow-through study: only if large bowel obstruction is ruled out

Upper GI study - Normal location of Duodeno-jejunal junction
Computed Tomography (CT)

- **RADIOSENSITIVITY**
  - Infants and young children are up to 10X more sensitive than adults
  - CT ONLY when REALLY INDICATED***

- **Use:**
  - Identifies small amounts of free intraperitoneal gas/fluid
  - Best evaluation for SBO
  - Inflammatory diseases
    - Appendicitis
    - Extraintestinal abscess/mass
    - Enteritis
    - Pancreatitis
    - Perianastomotic
    - Diverticulitis

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**Question #5:** What is a limiting factor in evaluation of pathology in an Abdominal CT of a child?

1. Lack of intra-peritoneal fat
2. Lack of intravenous (IV) contrast
3. Lack of oral contrast
4. All of above

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MRI in Acute Abdomen

- BEST modality for Pediatric and Pregnant patients for whom the risks of radiation or the potential nephrotoxicity of iodinated contrast agents is a major concern.
- Excellent modality for assessing pelvic abnormalities particularly in pregnant and pediatric patients.
- Disadvantages of MR imaging: include
  - High cost
  - Limited availability
  - Incompatibility of MR imaging systems and the equipment used for patient monitoring.

Nuclear Medicine Imaging

- Pertechnetate scan R/O Meckel's diverticulum
- HIDA scan R/O cholecystitis, mainly acalculous
- Tc-99 RBC scan R/O active bleeding
- In-111 WBC scan R/O abscess/infection
- DMSA- renal scan R/O acute pyelonephritis

99m-Tc Pertechnetate Scan

0.2mCi/kg
**Angiography**

- Percutaneous invasive angiography***
  - very rarely used

- Use:
  - Can help identify source of bleeding; diagnostic and therapeutic
  - Evaluation of aortic, celiac, and mesenteric vasculature

- Contraindicated in unstable patients with severe shock or sepsis

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**American College of Radiology (ACR) Appropriateness Criteria:**

**Variant 4:** Fever, leukocytosis, possible appendicitis, atypical presentation in children (less than 14 years of age).

1. US abdomen RLQ - 8
   - With graded compression.
2. CT abdomen and pelvis with contrast - 7
   - (May be useful following negative or equivocal US)
   - (Use of oral or rectal contrast depends on institutional preference.
   - Consider limited RLQ CT.)
3. X-ray abdomen - 6
   - May be useful in excluding free air or obstruction.
4. US pelvis - 5
5. CT abdomen and pelvis without contrast - 5
6. MR1 abdomen and pelvis without contrast - 5
7. CT abdomen and pelvis without and with contrast - 4
8. MR1 abdomen and pelvis without and with contrast - 4
9. X-ray contrast enema - 3
10. Tc-99m WBC scan abdomen and pelvis - 2

**Rating Scale:**

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

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**BEST Approach to Acute Abdomen**

- **US*** ALWAYZ first and initial!
- Plain Radiography (CXR, AXR)
- CT
  - Contrast Studies: Upper GI study, Small bowel series, Enema, IVP
  - MR1
  - Nuclear Imaging
  - Angiography
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Neonatal
- Necrotizing Enterocolitis
- Midgut volvulus
- Meconium Ileus
Necrotizing Enterocolitis

- Idiopathic in VLBW premature infants
- Morbidity best in FEMALE and BLACK
- Morbidity worst in MALE and WHITE
- Bowel dilation
- Bowel wall thickening
- Pneumatosis/Intramural air
- Portal venous air
- Rigler's Sign - free air outlining bowel

Mid-gut Vovulus
Malrotation with Volvulus

- Neonates (>50% under 1 month old): Bilious/Non-bilious emesis, abdominal discomfort
- Older children: Acute or chronic episodic vomiting and abdominal pain
- "Corkscrew" appearance on Upper GI series
- Anomalous location of the duodenojejunal flexure
- Proximal jejunal loops in the right upper quadrant
- Can lead to infarction of bowel

Meconium Ileus

Neonatal obstruction of the distal ileum due to abnormally thick, tenacious meconium.
- Multiple dilated bowel loops
- Soft tissue mass/Soap bubble appearance
- Smallest microcolon
TT: Serial hyperosmotic water soluble enemas versus surgery
Meconium Ileus---nearly ALWAYS Cystic Fibrosis
10-20% Cystic Fibrosis---Meconium Ileus
Cystic Fibrosis --- Caucasian
Infant
- Intussusception
- Pyloric Stenosis
- Bowel Obstruction
- Battered Infant
  - Duodenal hematoma
- Gastroenteritis
- Urinary Tract Infection

14-month-old girl with poor feeding and intermittent vomiting.

10-month-old boy with 1-day history of irritability, vomiting, and intermittent crying.
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Intussusception
- Invagination of a part of the intestine into itself
- Sudden, severe, colicky intermittent pain
  - May have mass in R abdomen
  - “Currant Jelly” Stools
- Plain radiographs - poor sensitivity & specificity
- Ultrasound - very sensitive
- Enema - diagnostic & therapeutic/reduction
  - Contraindicated: free air, peritoneal signs
  - Air OR Water-soluble positive-contrast media may be used
- Rule OF 3’s: 3 months - 3 years of age
  - 30% dilution, 3 feet high, 3 Attempts

Pyloric Stenosis
Pyloric Stenosis

15 months old Nigerian Baby-Boy with h/o intuss' @ 7 months of age, s/p bowel resection

NOW closed loop obstruction with perforation, 10 cm ileum resected.

SBO

- Hx of previous abd surgery
  - 1% - 5% develop adhesions w/in 5 years of surgery
  - Most at risk: multiple procedures, surgery on ileum, peritonitis
- Present w/ abd pain, vomiting, shock
Common abdominal processes that may cause bowel obstruction

- Appendicitis
- Adhesions
- Intussusception
- Incarcerated Inguinal hernia
- Mal-rotation with Midgut volvulus
- Meckel diverticulum

Child

- Constipation
- Urinary Tract Infection
- Lower lobe Pneumonia
- Appendicitis
- Mesenteric Lymphadenitis
- COLITIS
- Intussusception or Volvulus (children under age 3)
- Abdominal trauma
Foreign Body Ingestion

- More common in young children
- Most small, smooth objects eliminated w/ difficulty
- Emergent evaluation:
  - Sharp objects - perforation bowel
  - Objects >5 cm in length - obstruction
  - Multiple magnets - entrapment and ischemia of bowel
  - Button batteries - caustic reaction
4 years old with pyelonephritis

12-year-old boy h/o open appendectomy 3 years ago now with nausea, N/V vomiting x 1 day.

CT shows a transition point in the right lower quadrant. Diagnostic laparoscopy with lysis of adhesions > 90 minutes. No bowel resection.
9 y old girl
Acute Appendicitis

17 y old boy

14 y old boy
Appendicitis

- Clinical features:
  - Pain in the RLQ
  - Abdominal wall rigidity
  - Migration of periumbilical pain to RLQ
- May not all be present, especially in younger children (most cases > 5 yo)
- High index of suspicion:
  - Hx of abd pain and vomiting, with or without fever or focal abdominal tenderness.
  - Ruptured Appendicitis with pelvic abscess in Latino patients (OVMC observation)

CT Findings

- Normal appendix is 1 to 2 mm in wall thickness with an overall diameter of 8 mm.
- The abnormal appendix will show a thickened wall >3 mm and a distended lumen ≥8 mm.
- Appendolith, mesenteric fat infiltration or fluid, adenopathy OR abscess formation
- In a recent report on the CT diagnosis of appendicitis, the most common signs of acute appendicitis included
  - Fat stranding (100%),
  - An enlarged appendix >6 mm in lumen width (97%),
  - Adenopathy (63%), and
  - An appendicolith (42%).[17]
Mesenteric Lymphadenitis

- Inflammatory condition of the mesenteric
- Viral > bacterial
  - Gastroenteritis (e.g., Yersinia), Group A Strep pharyngitis, IBD, and lymphoma
- Can present with acute or chronic abd pain
- Can mimic appendicitis: LRQ abd pain
- Diagnosed by US:
  - abd LN > 10 mm
  - Large LNs do NOT exclude appendicitis

Adolescent

- Appendicitis
- Gastroenteritis
- Constipation
- Gynecologic cause
  - Pregnancy (or Ectopic Pregnancy)
  - Dysmenorrhea
  - Pelvic Inflammatory Disease
  - Ovarian torsion
- Testicular Torsion
- Gallbladder disease
- Neoplasm
- Inflammatory Bowel Disease

18y old h/o appendectomy @ age 12

SBO
Ectopic Pregnancy

- Postmenarchal girl
- Abdominal pain, amenorrhea, and vaginal bleeding with or without rupture
- Typically 6-8 weeks after missed period
- Increased risk: hx of STD, previous ectopic pregnancy
Transverse Vaginal septum

Teenage girl with abd pain
Ovarian/Testicular Torsion

- **Ovarian torsion**
  - Usually assoc w/ ovarian mass or cyst
  - Nausea, vomiting
  - Can be partial or intermittent with intermittent abdominal pain

- **Testicular torsion**
  - Scrotal pain, may radiate to abdomen
  - Nausea, vomiting, and fever
  - Testis: tender, swollen, slightly elevated

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13 y old girl with RUQ pain

**Acute Cholecystitis**
NUCLEAR IMAGING : HIDA scan

Acute Cholecystitis

- RUQ or epigastrum pain +/- radiation to R shoulder or back
- N/V, anorexia
- Relatively uncommon in peds
- Increased risk:
  - Hemoglobinopathies (Eg SICKLE CELL Ds in African-American child)
  - Cystic fibrosis (White/Caucasian child)

18 years old boy

Acute Diveriticulitis

Increasing incidence in young population.
C. Diff Pseudo-membranous colitis.

Visceral injury s/p fall from skateboard.
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THANK-YOU for your Attention!

References