

# Challenges of Imaging Pediatric Abdominal Emergencies

Susan D. John, M.D.

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THE UNIVERSITY *of* TEXAS

HEALTH SCIENCE CENTER  
AT HOUSTON

# 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**

1

# 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



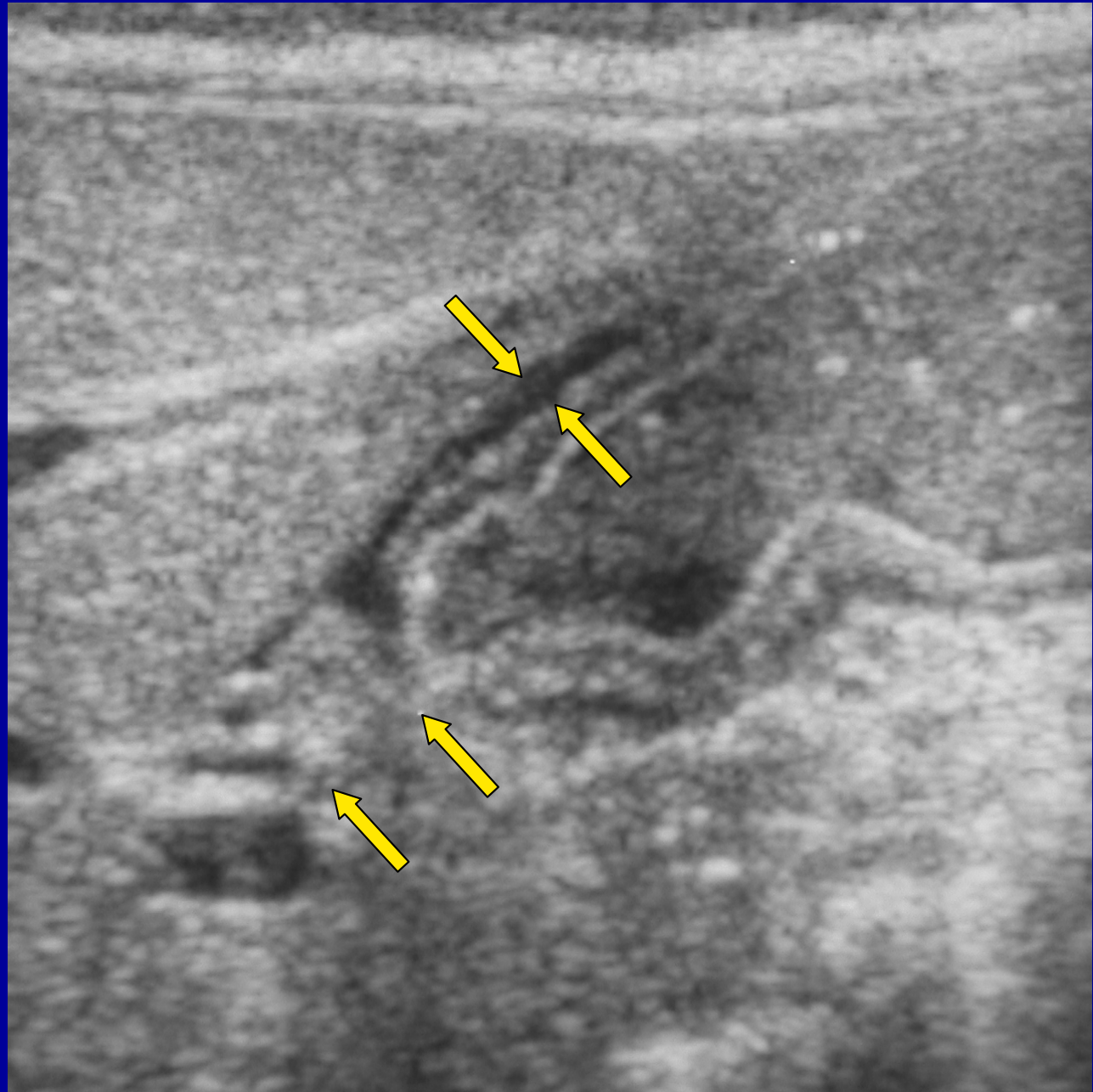
# Hypertrophic Pyloric Stenosis

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

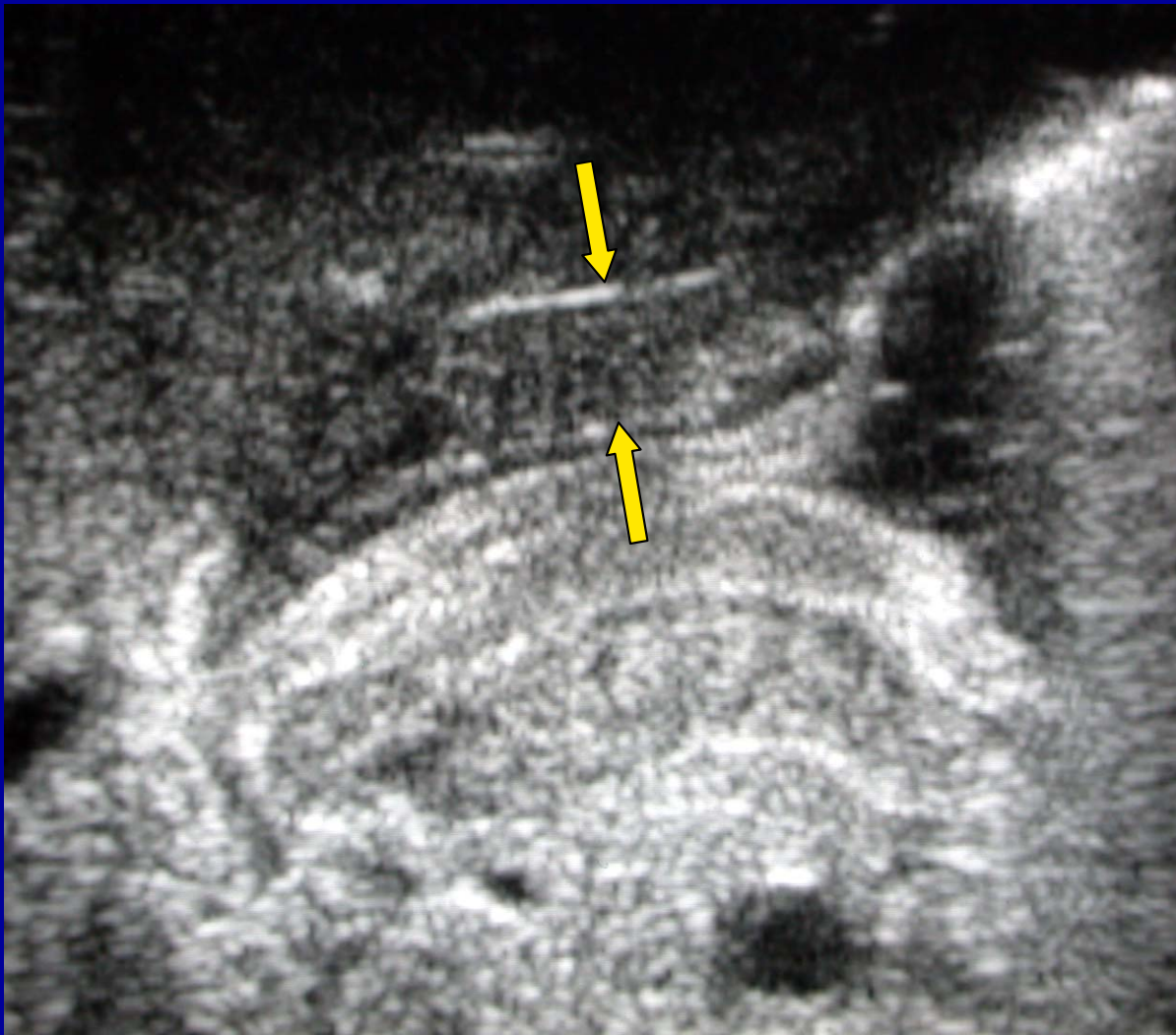


# Normal Pylorus

- 1-2 mm muscle
- Length negligible
- Opens frequently







Longitudinal

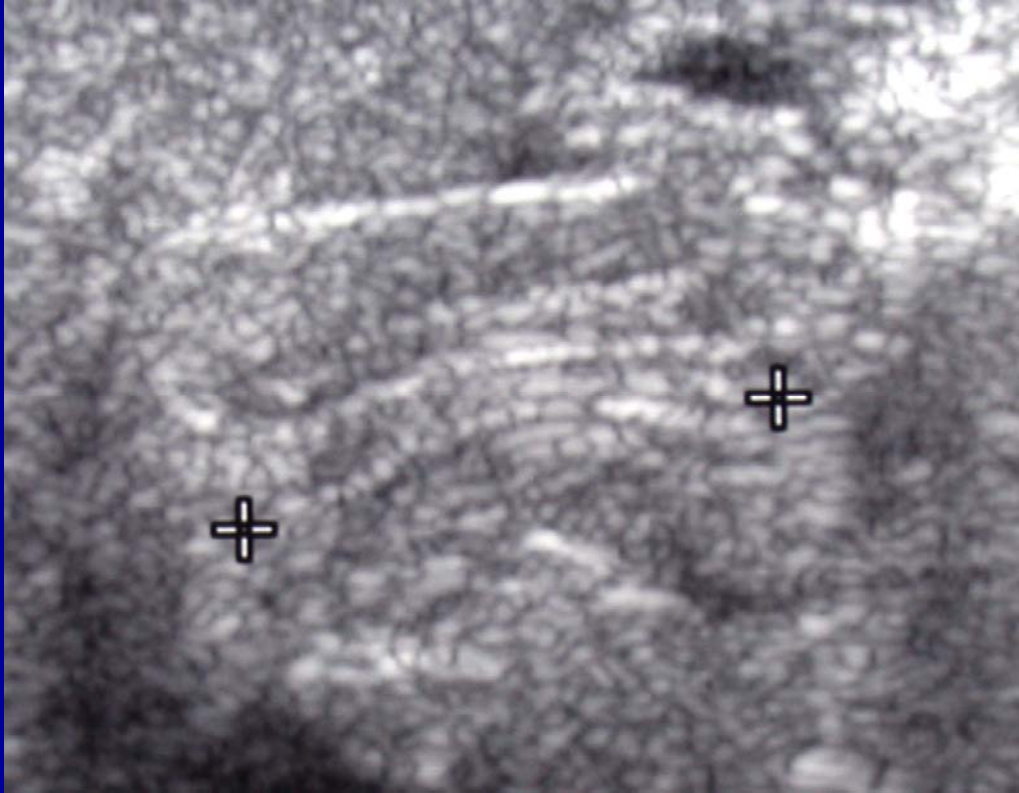
- 3 mm + muscle
- 1.5 cm + length
- Little or no emptying

## Hypertrophic Pyloric Stenosis

Transverse



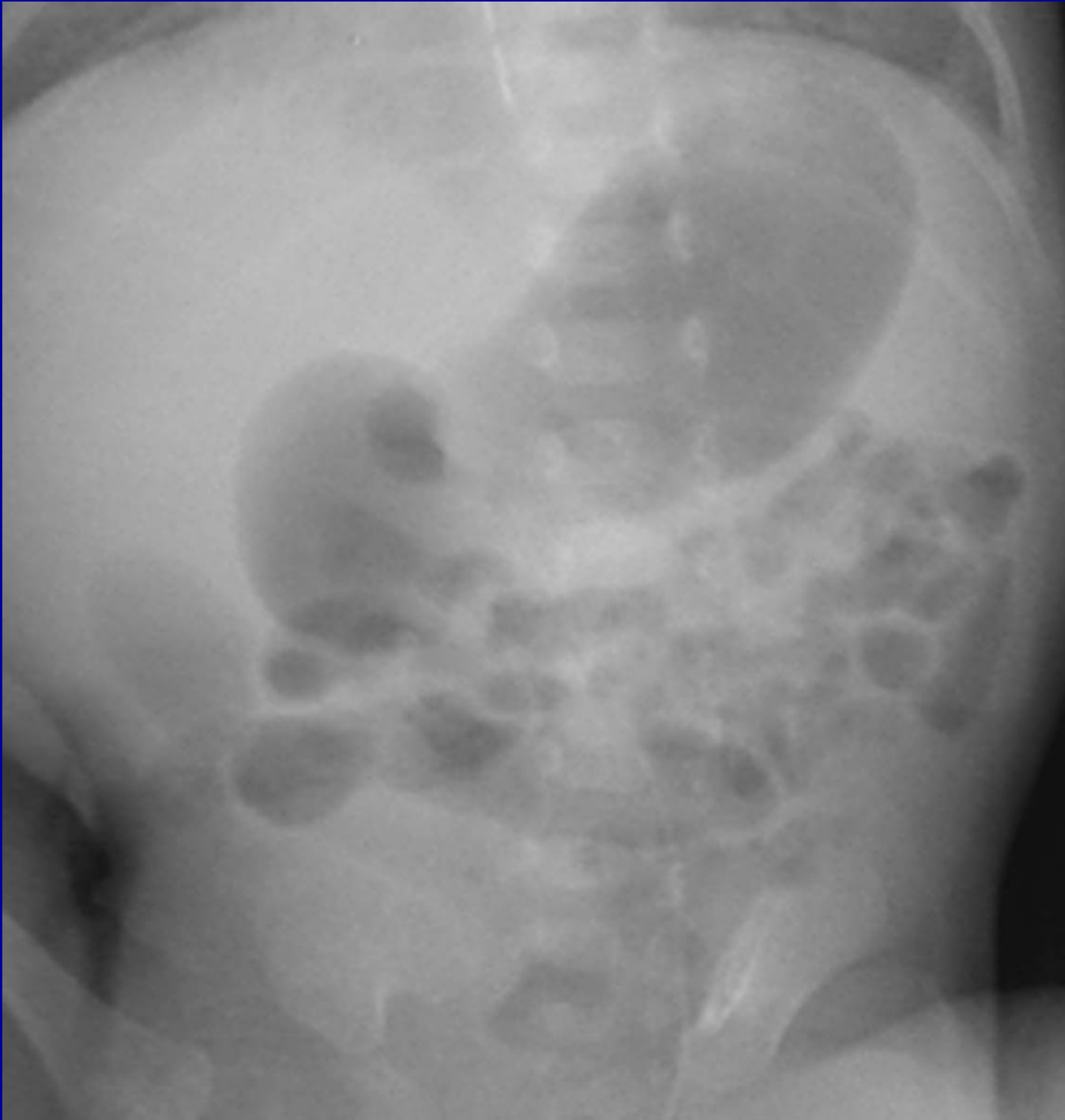
# Pitfall – the empty stomach!



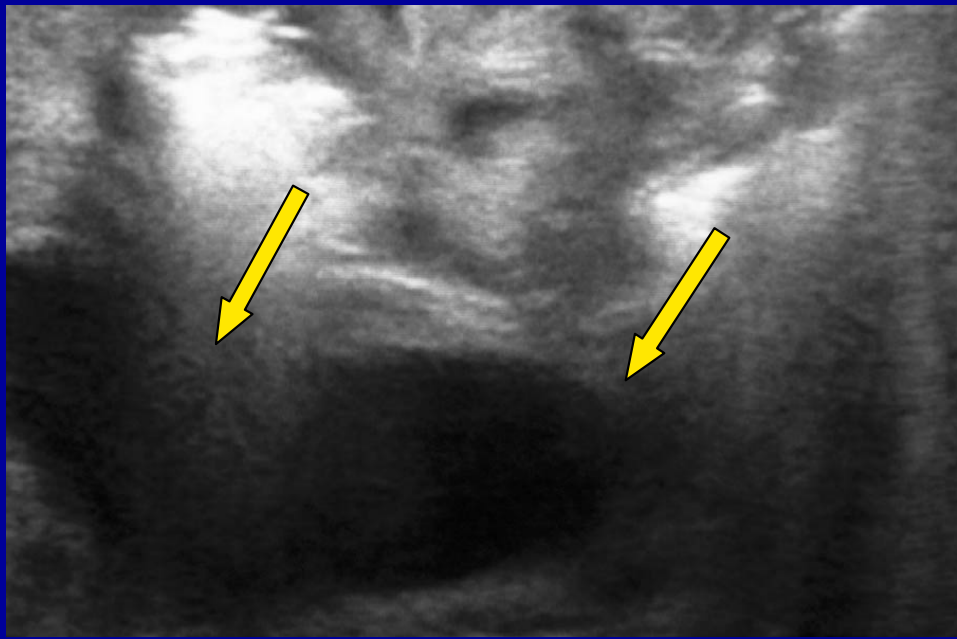
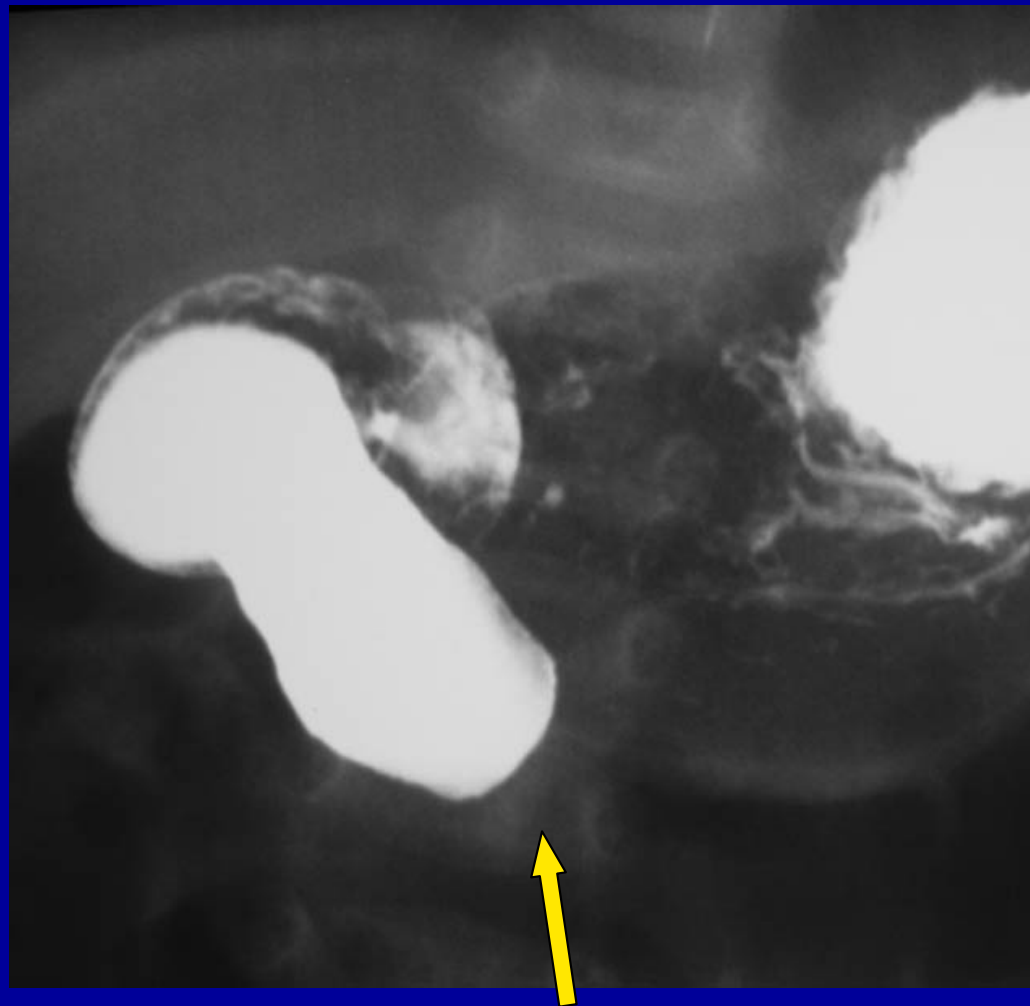
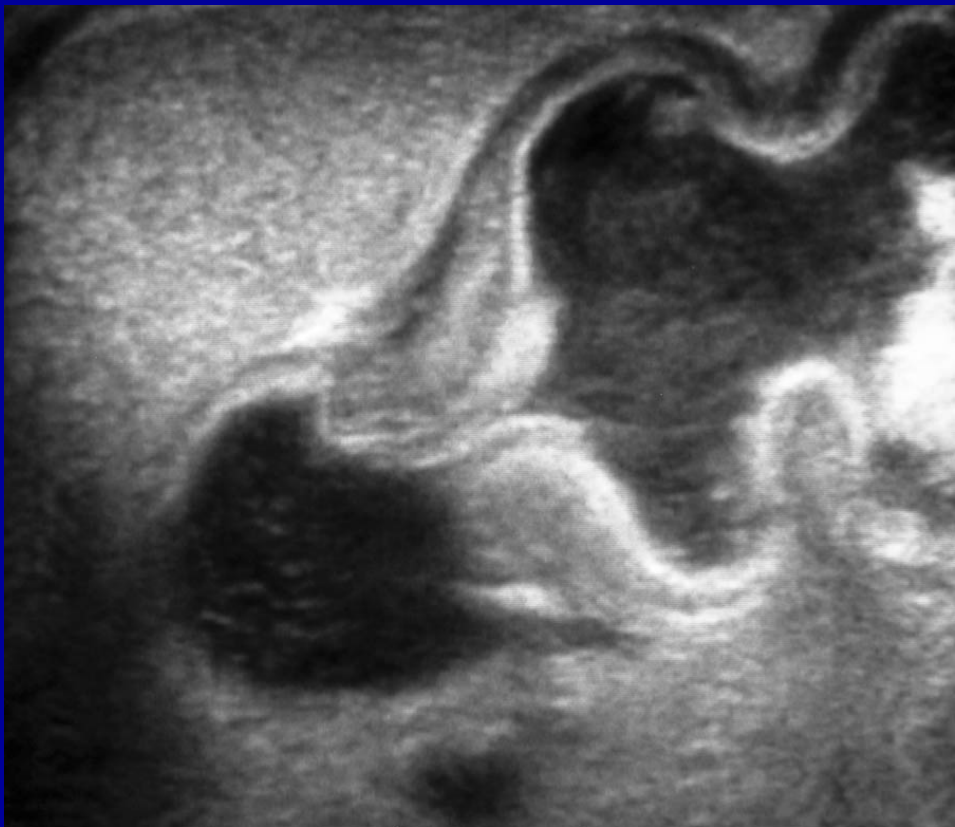
- Administer fluid (sugar water), if needed
- Oblique patient to right

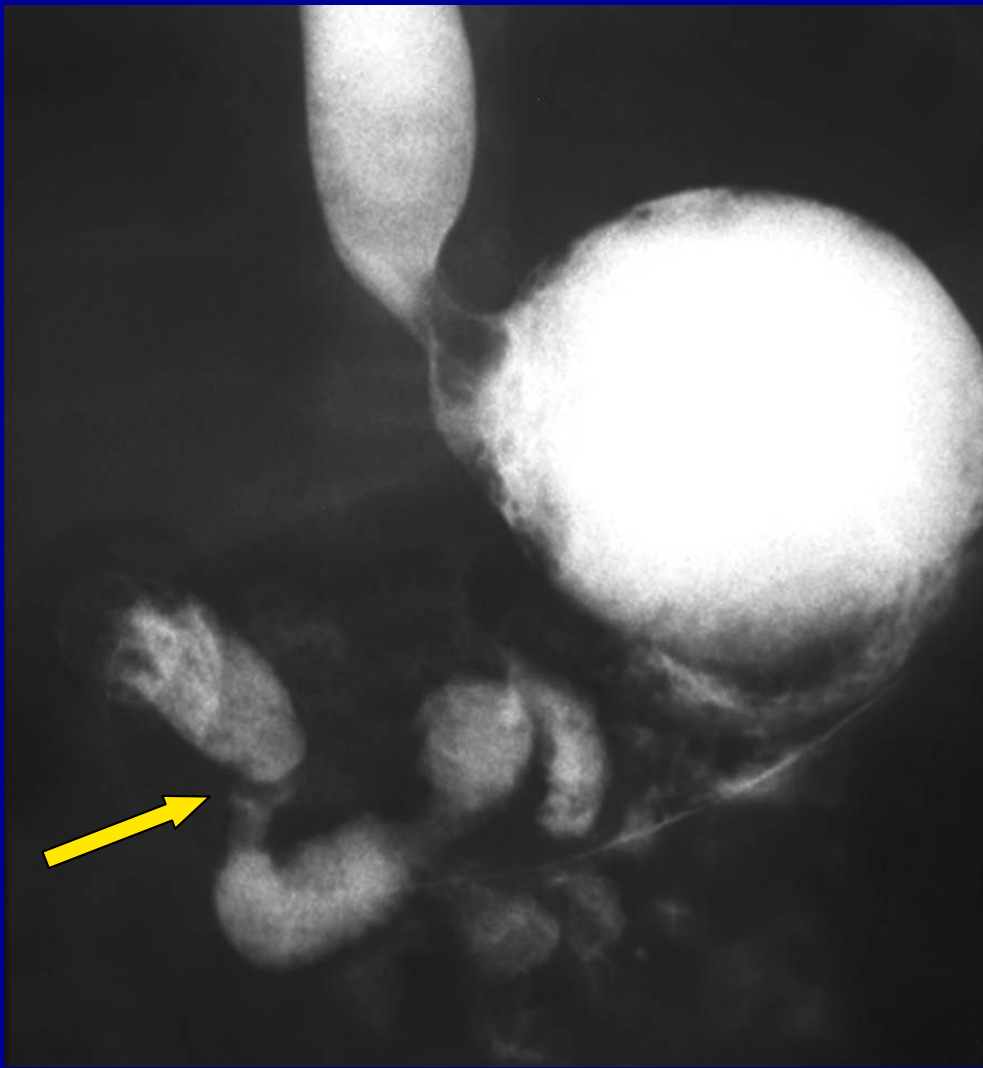
# **Congenital/Developmental Abnormalities**

- **Incomplete duodenal obstruction**
  - **Diaphragm**
  - **Stenosis**
- **Acute duodenal obstruction**
  - **Midgut volvulus**
- **Colon obstruction**
  - **Hirschprung disease**

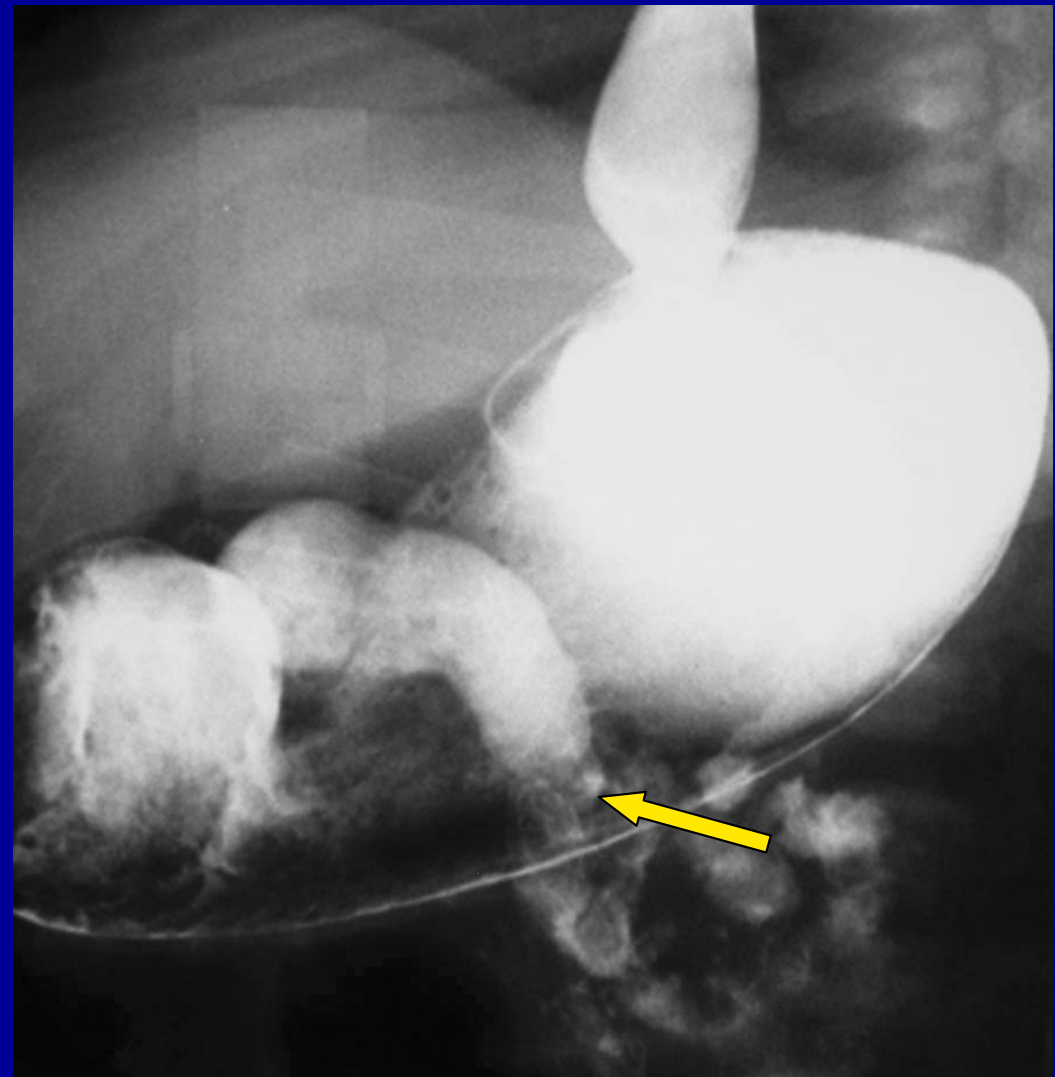


3 month  
old with  
increasing  
vomiting





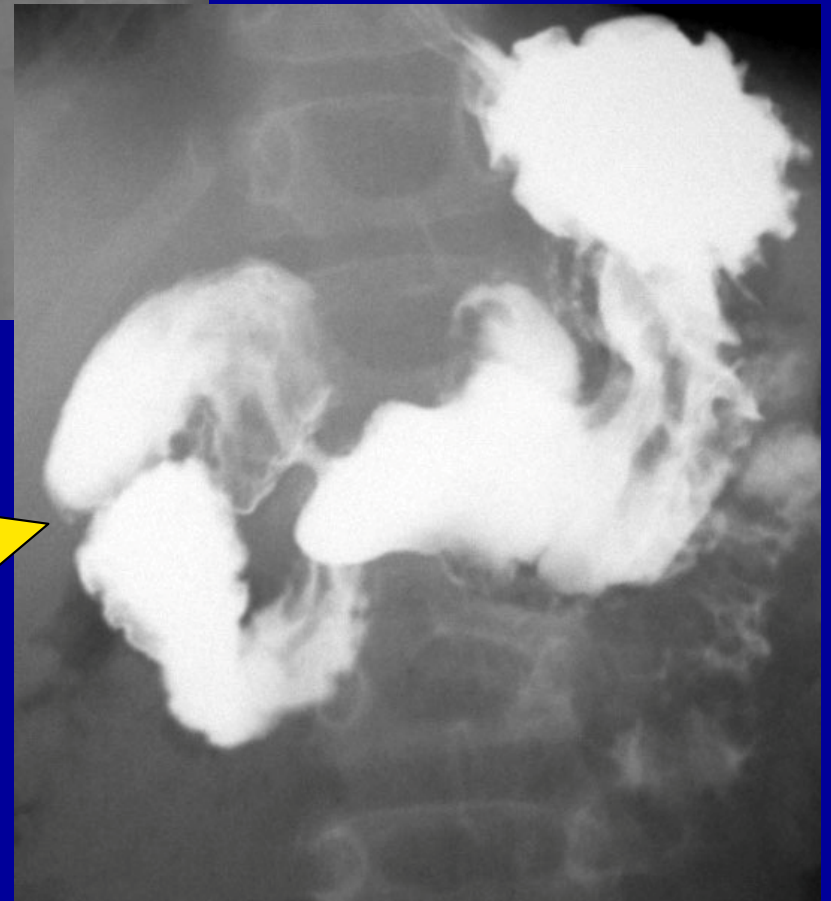
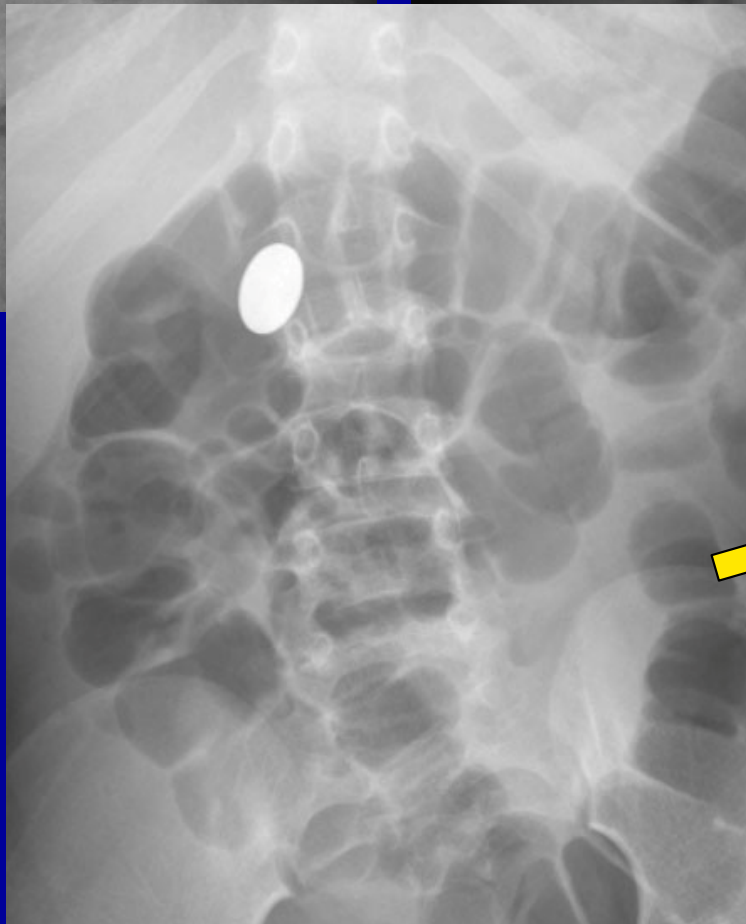
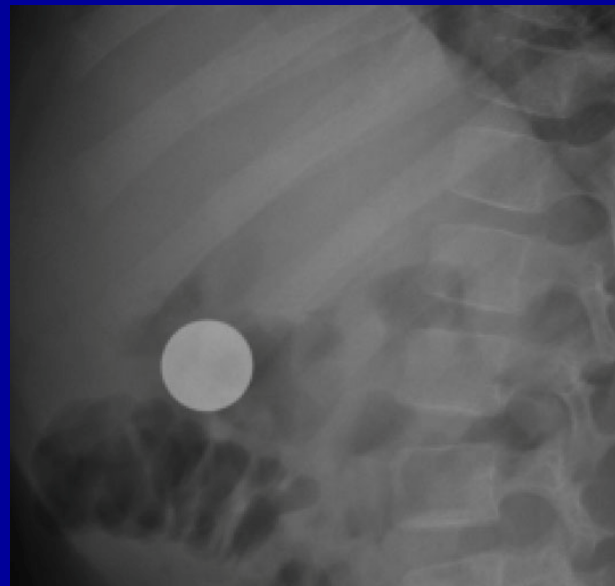
Duodenal Web

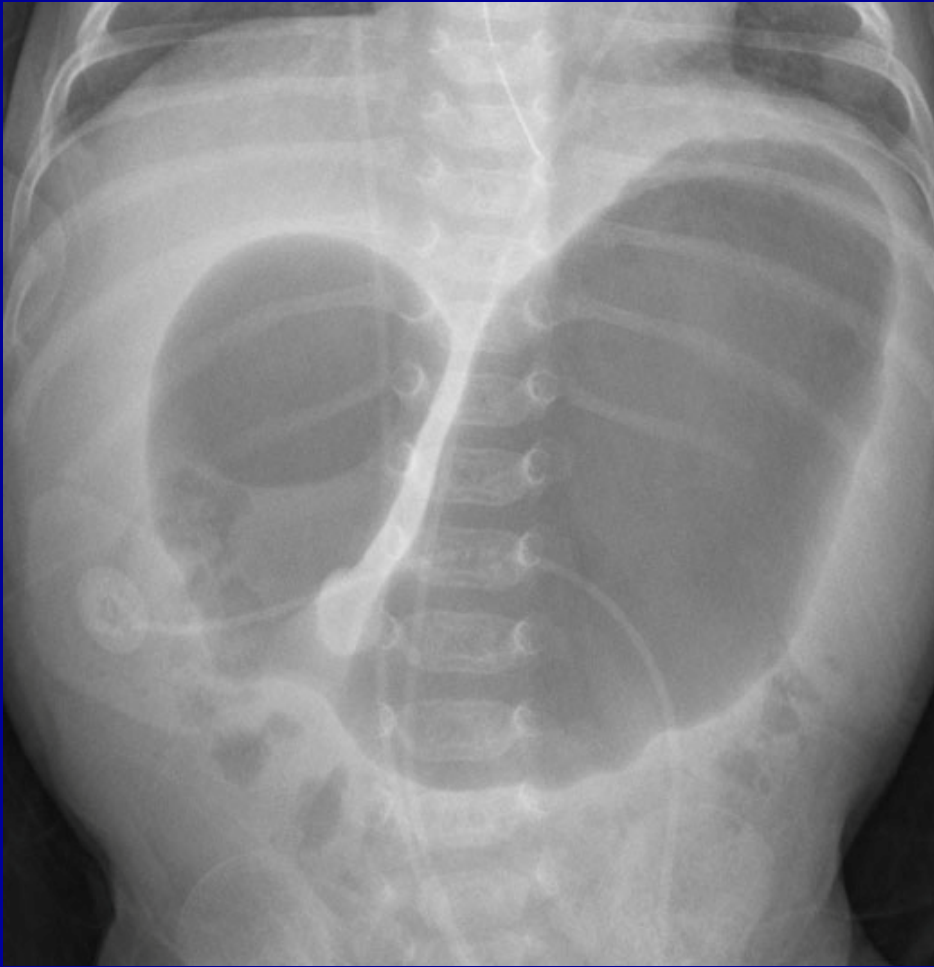


Early incomplete obstruction  
can progress to complete  
obstruction later

## Duodenal Web

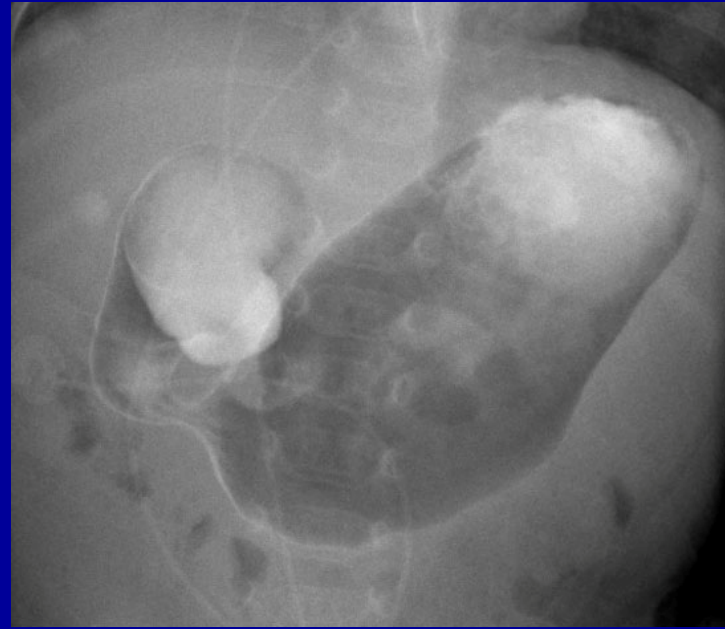
- Incomplete obstructing band
- Second portion of duodenum





7 week old with vomiting

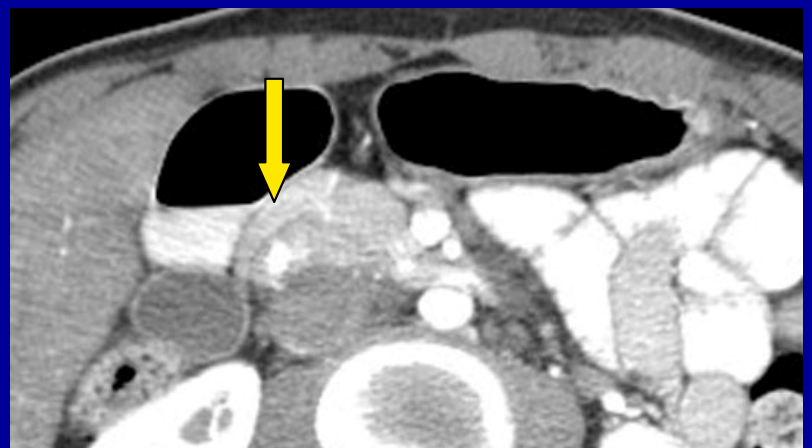
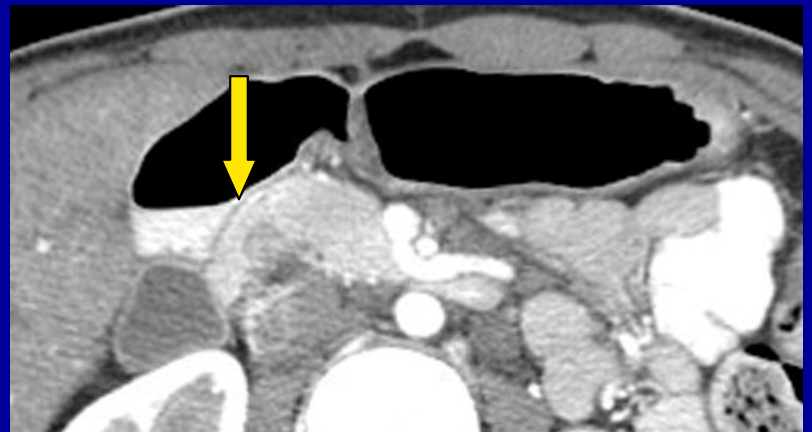
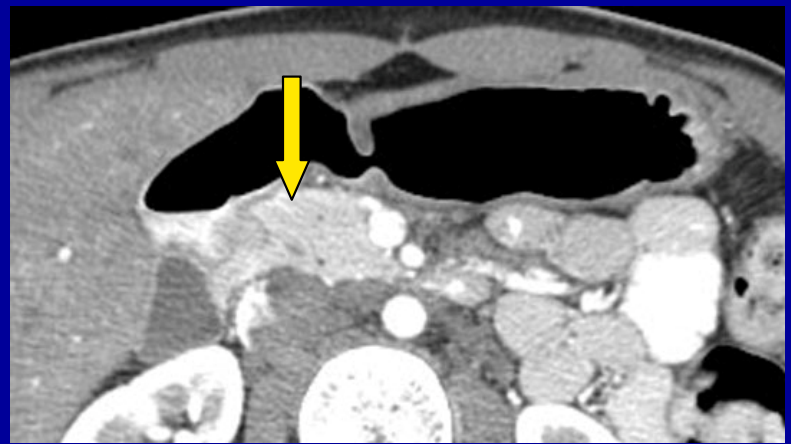
## **Annular Pancreas**







**17 year old with new  
onset abdominal pain  
with meals**

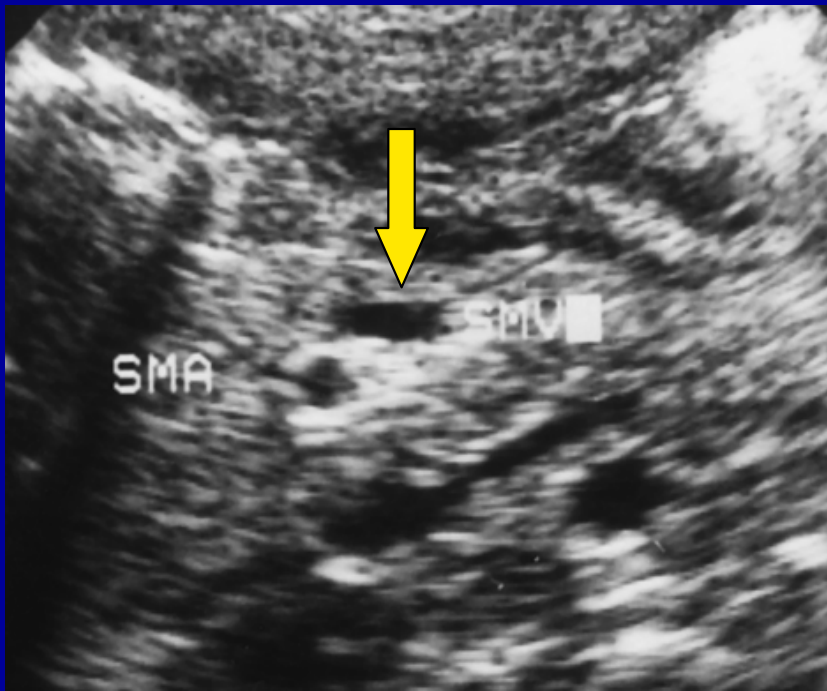


**Annular Pancreas**

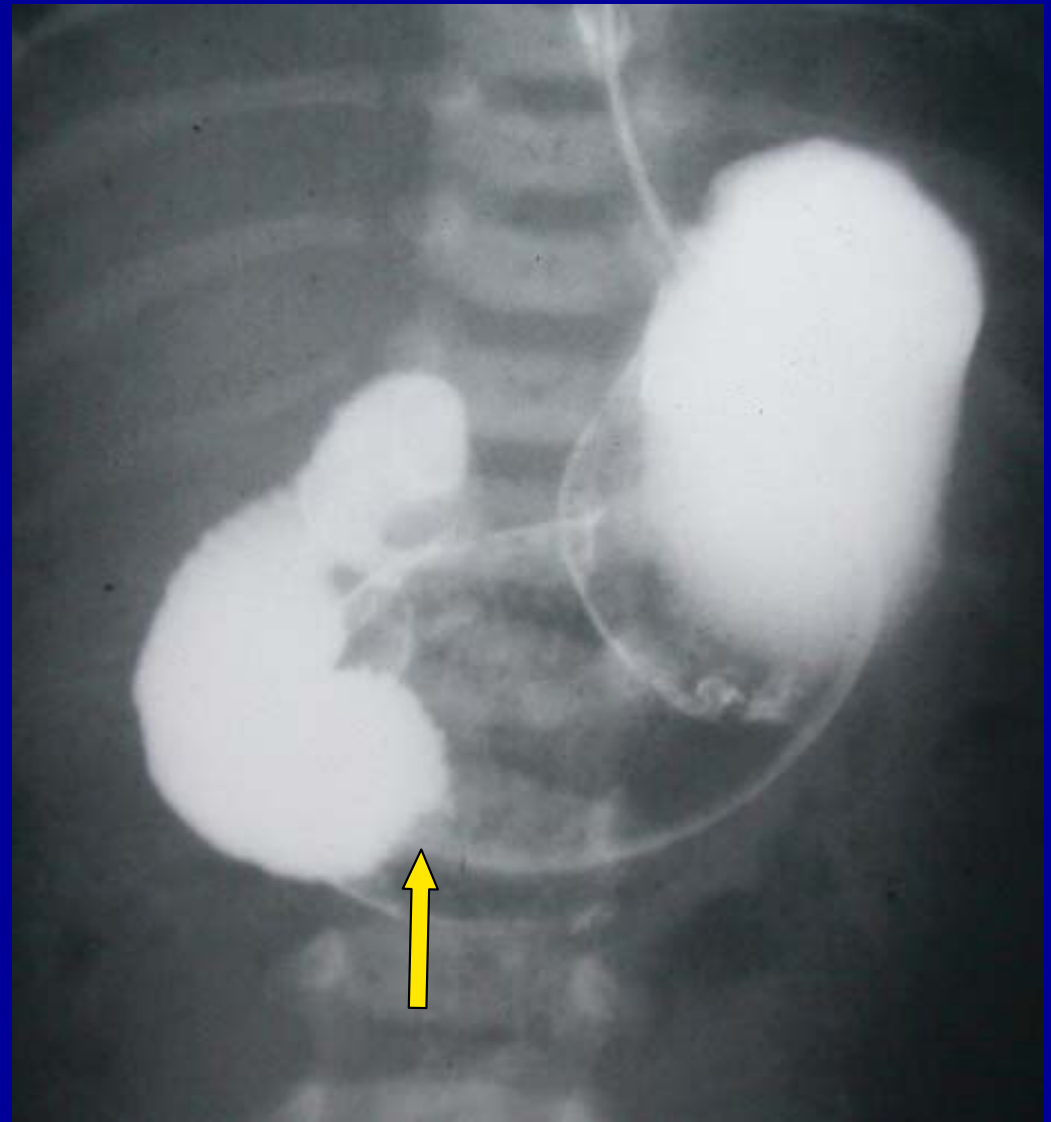
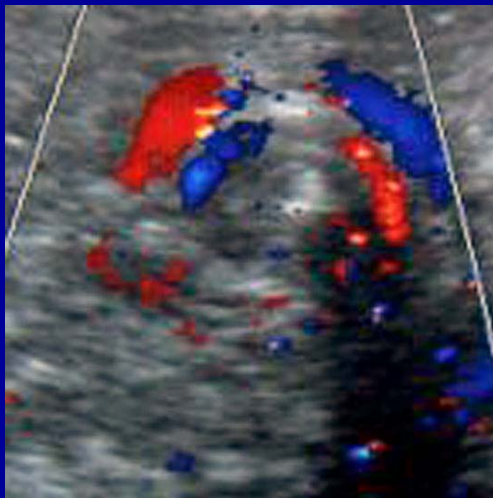
# Midgut Volvulus

- Acute obstruction
- Minimal findings on radiographs
- Contrast exams versus US

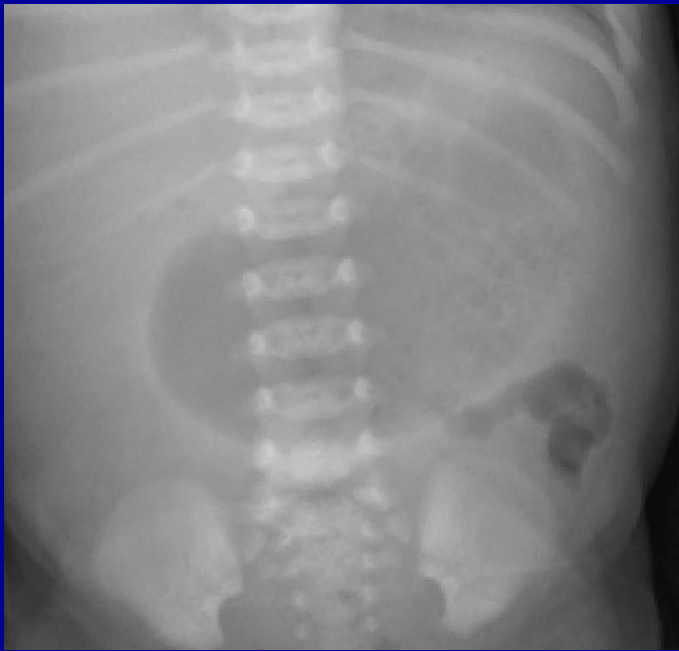




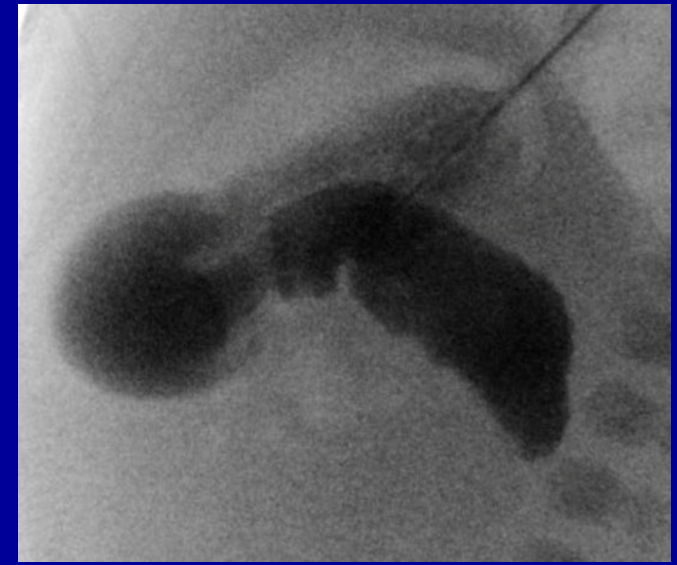
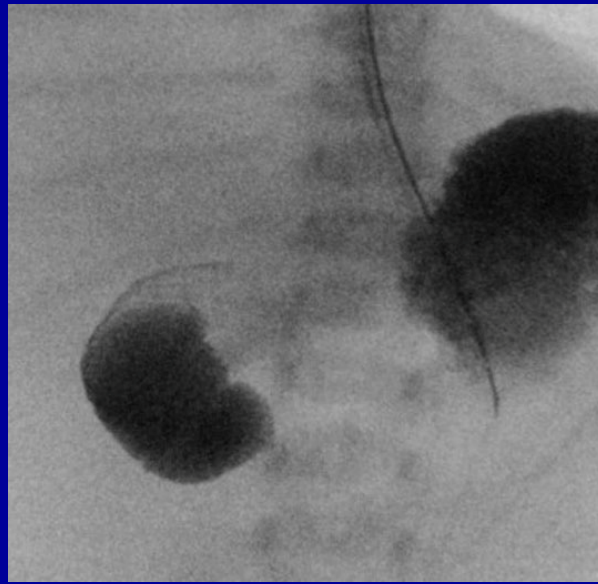
**SMV normally lies to the right of SMA**



Obstruction 3<sup>rd</sup> portion of duodenum = midgut volvulus

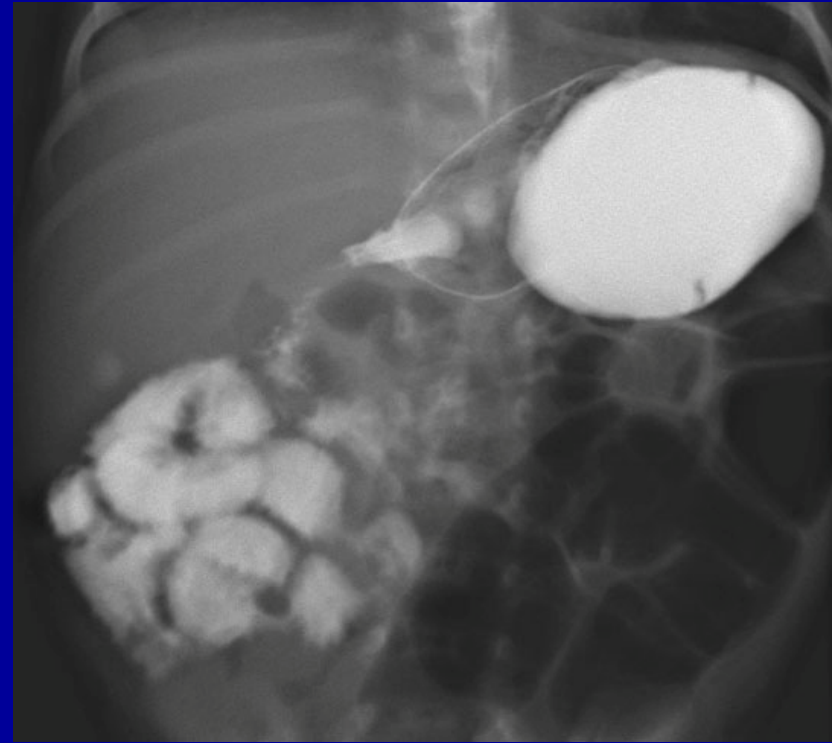


1 week old  
with vomiting

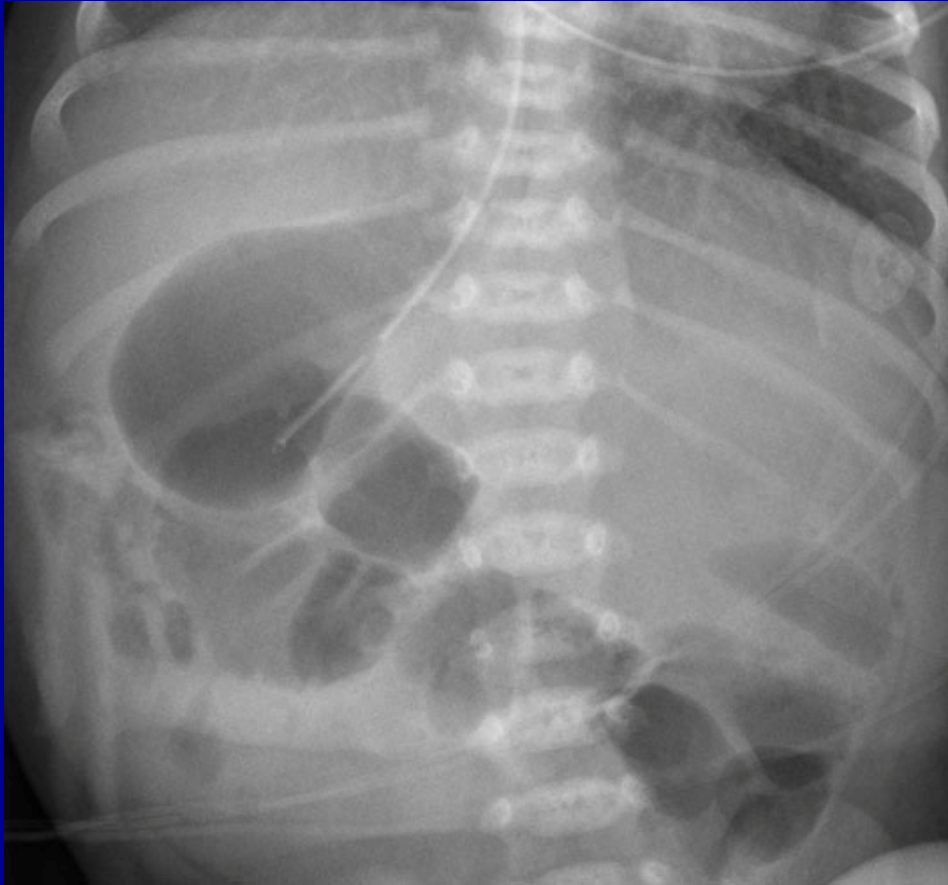


## Midgut Volvulus

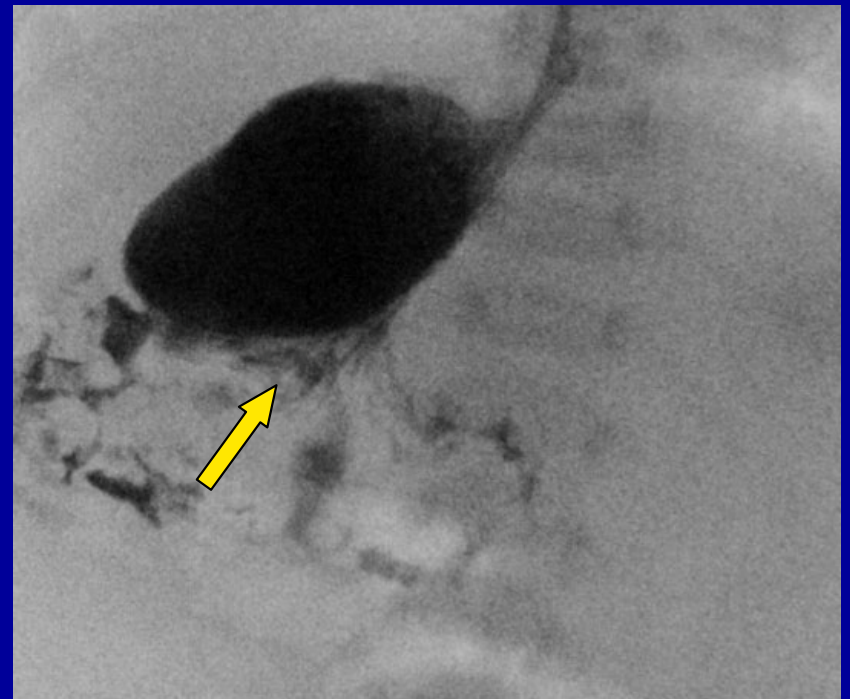
Recurrent  
vomiting 2 wks  
s/p Ladd's  
procedure

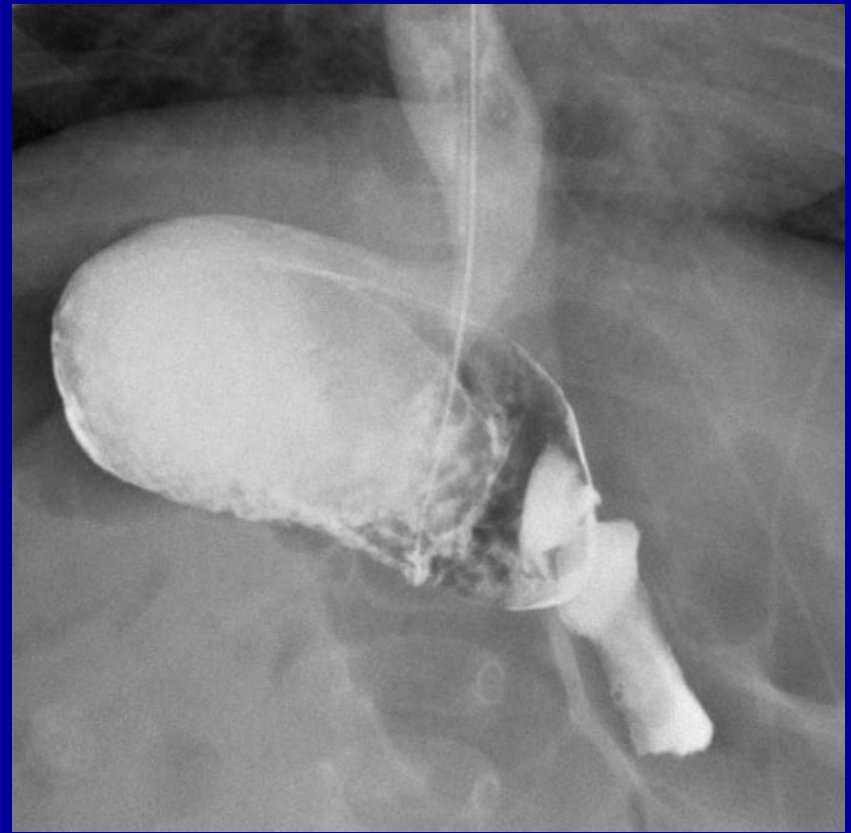
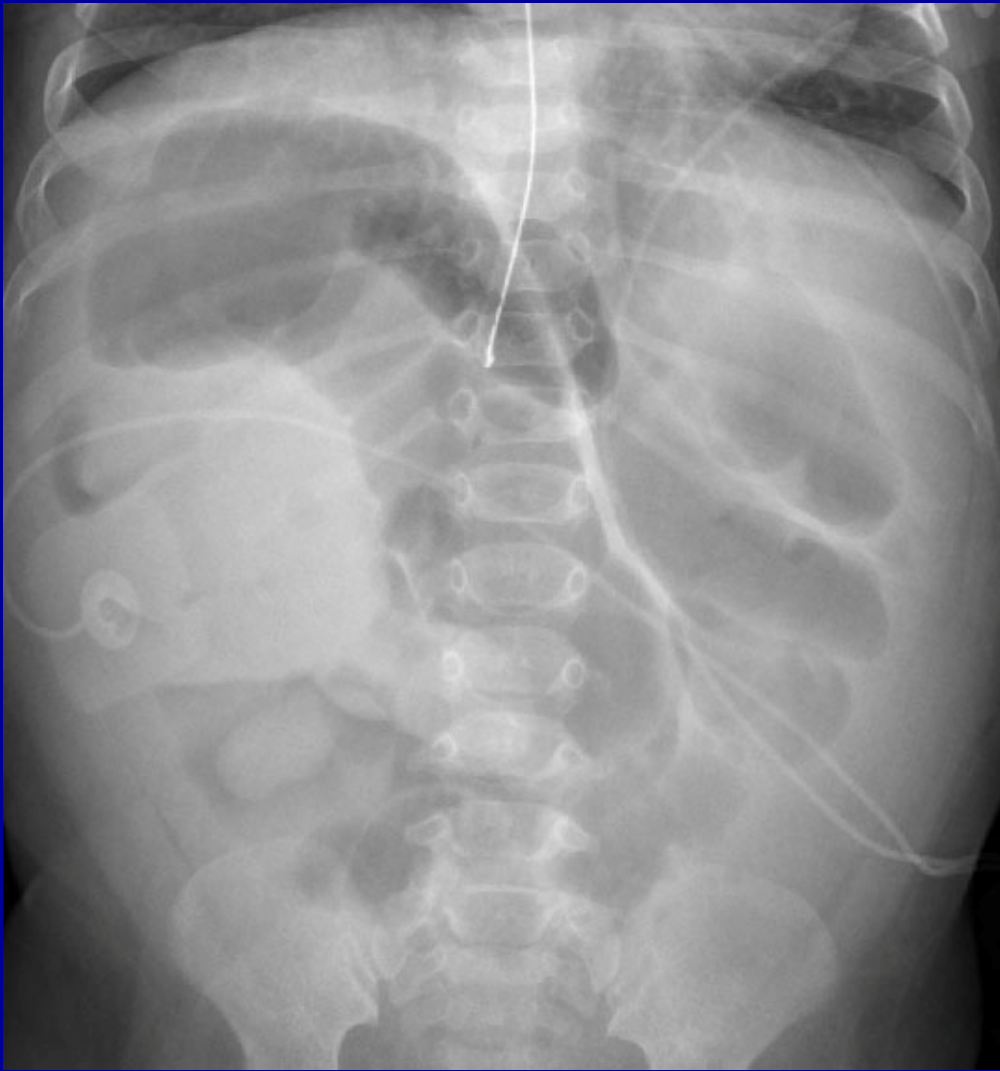


# Abdominal Heterotaxy and Volvulus

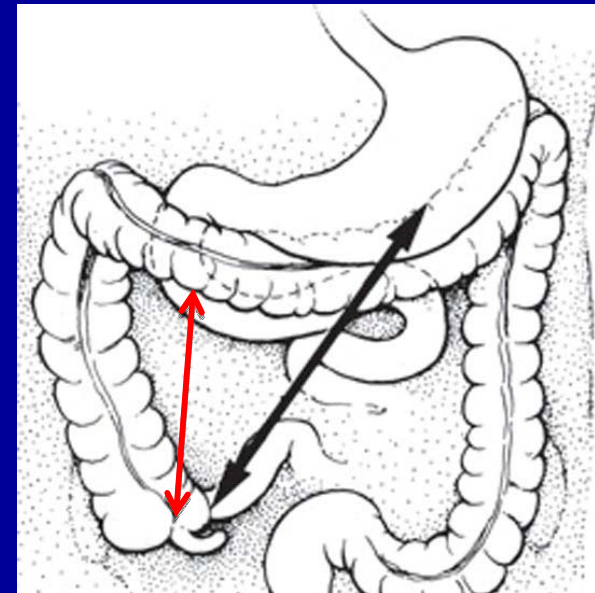


- High incidence of malrotation in children with abdominal heterotaxy





**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 2<sup>nd</sup> portion of the duodenum.**
- 4) Requires emergent surgery when complete obstruction occurs in 3<sup>rd</sup> 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



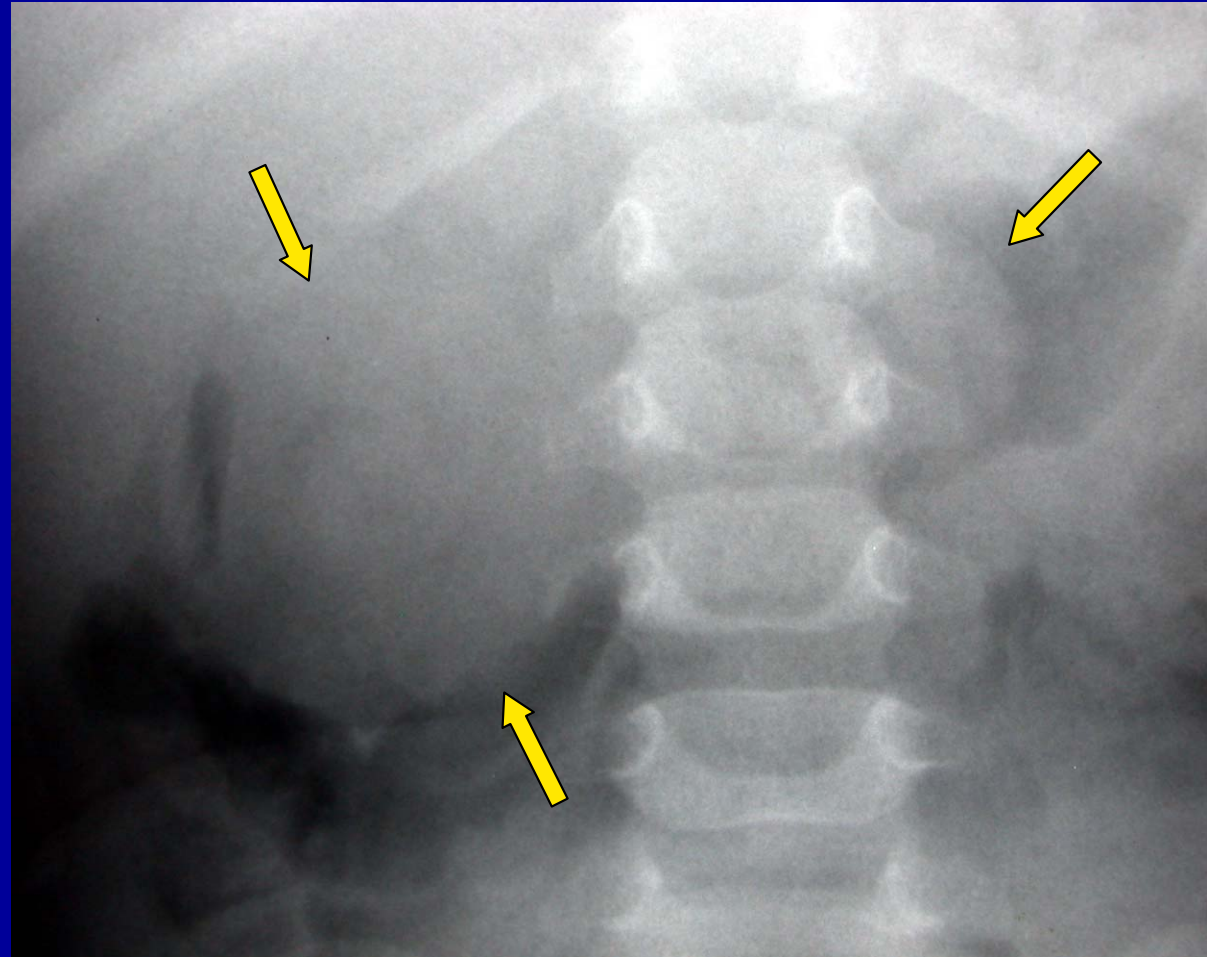


# Intussusception

- **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**

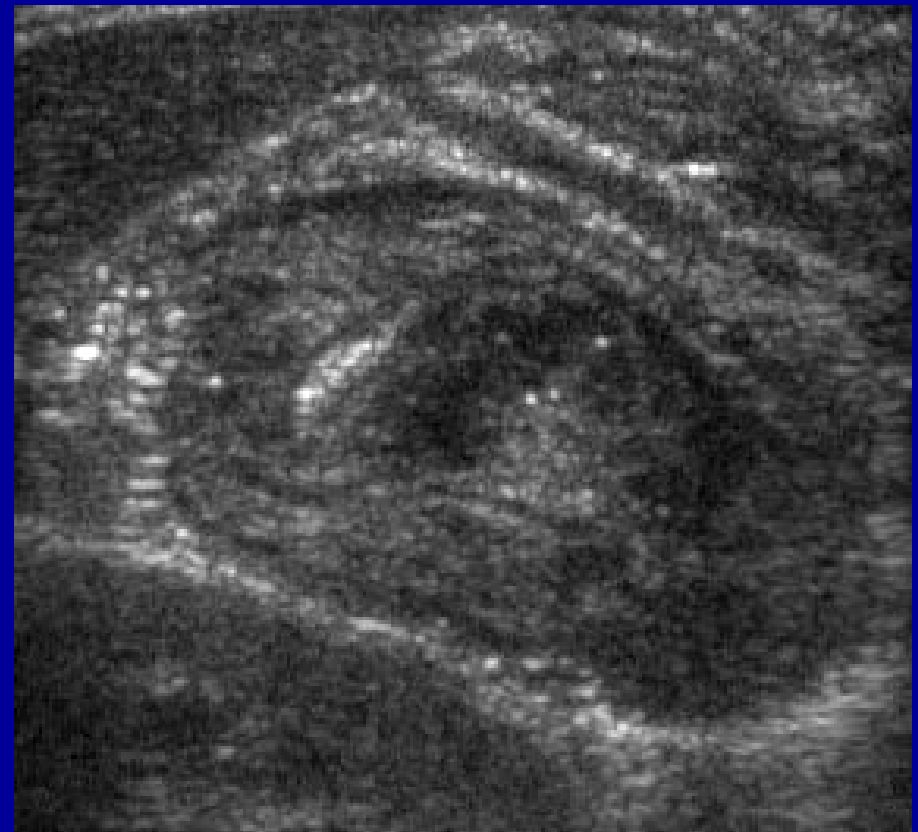
# Radiographs

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

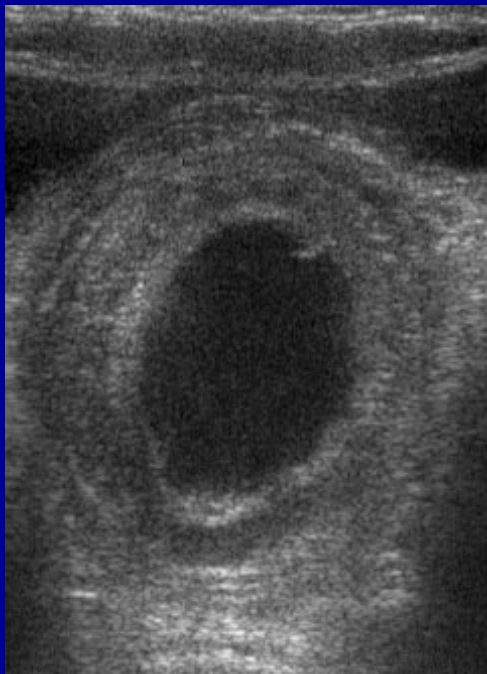


# Ultrasound for Intussusception

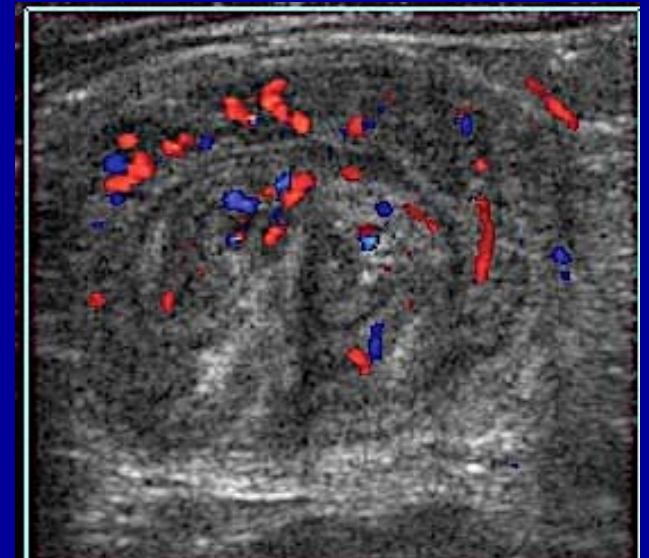
- High frequency (7-12 MHz) transducer
- Complex mass
  - Target, donut appearance



- High sensitivity and specificity
- If US negative, contrast enema not needed

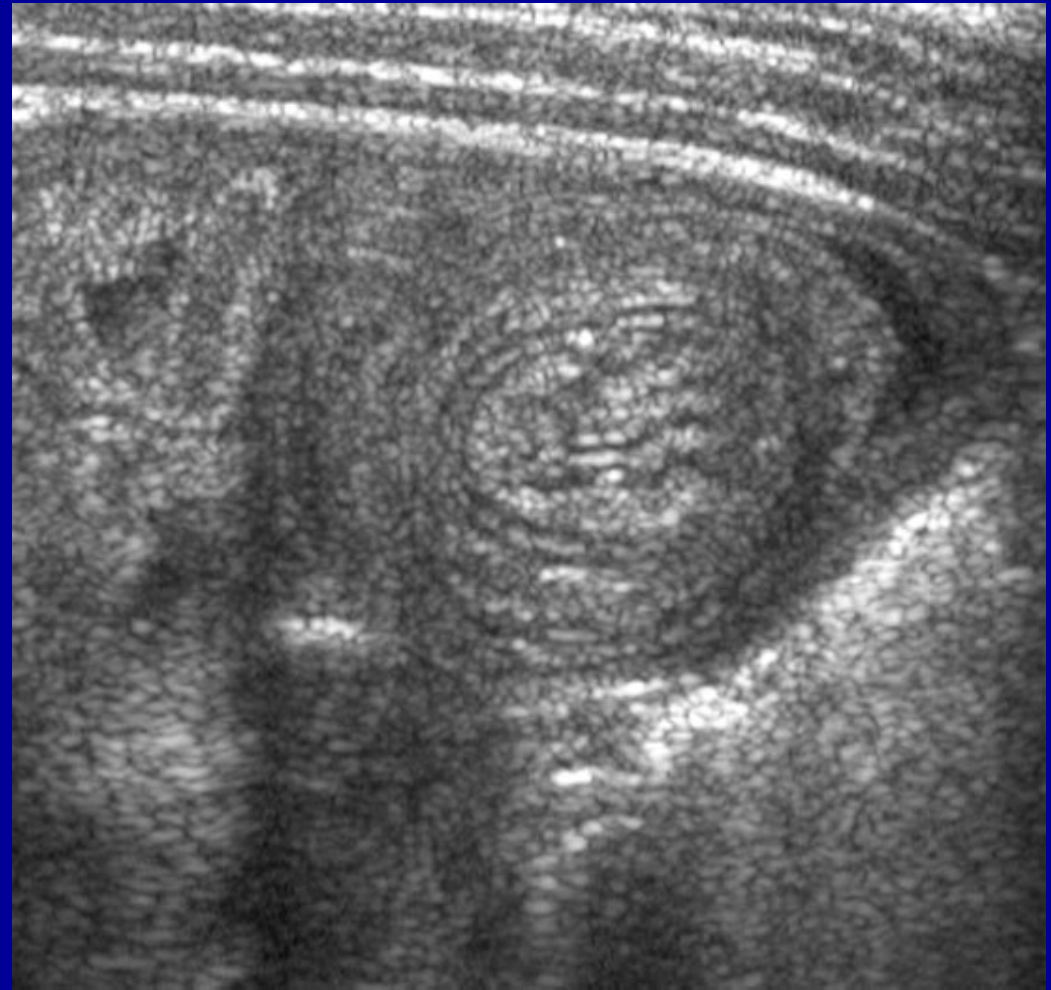


Lack of flow with Doppler suggests ischemia, but not a contraindication to non-surgical reduction



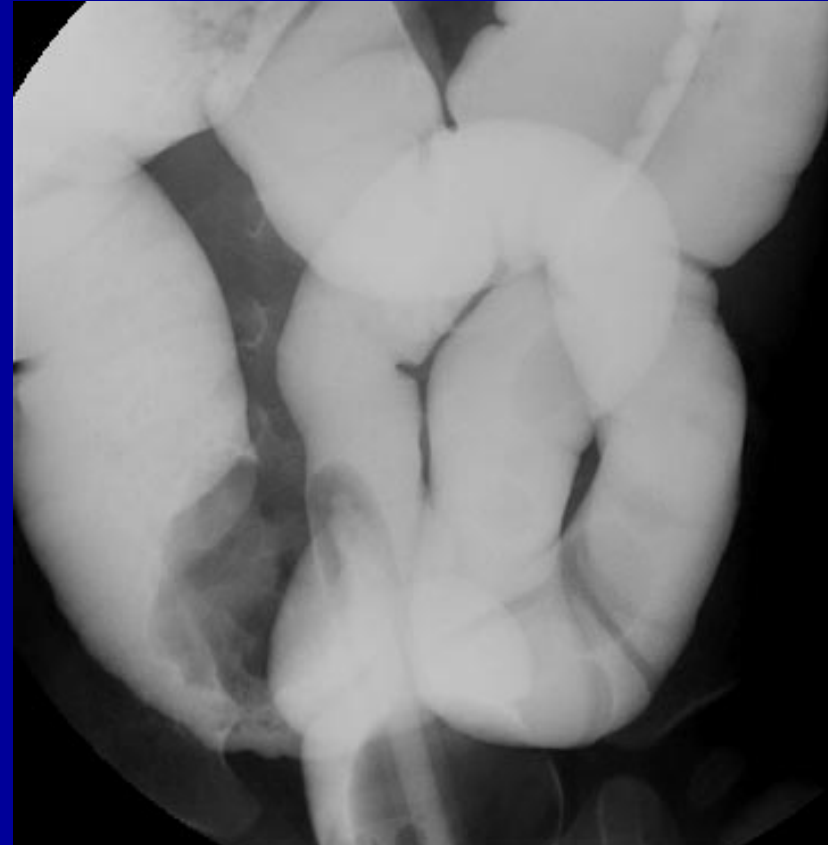
# Transient Intussusception

- Common in patients with hyperperistalsis



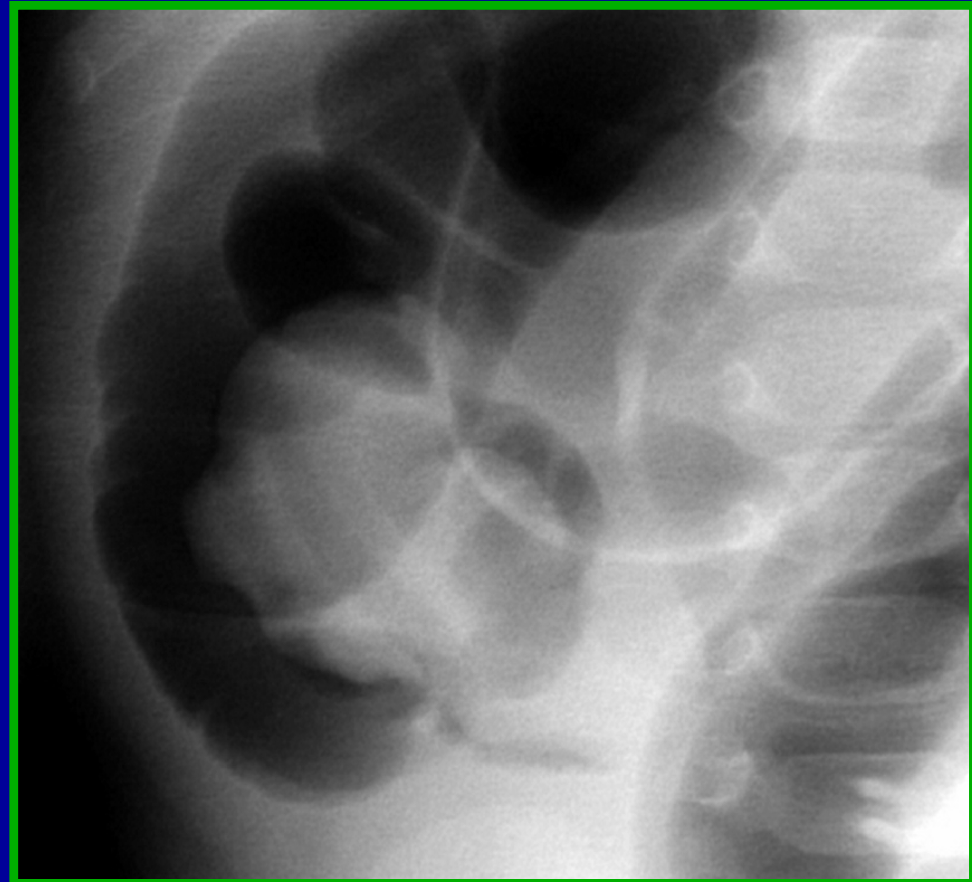
# Non-surgical Reduction

- **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**

**3**

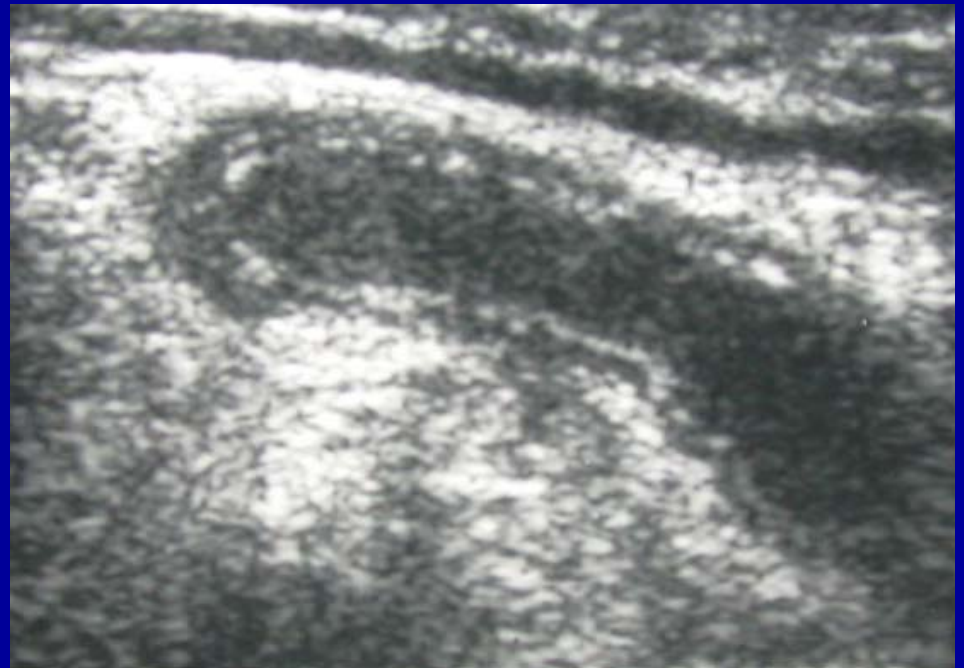
**In my practice, the initial imaging study performed on children with suspected appendicitis is:**

- 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**  
**“abnormal”**
  - PPV – 63%
  - NPV – 100%
  - More useful for excluding appendicitis

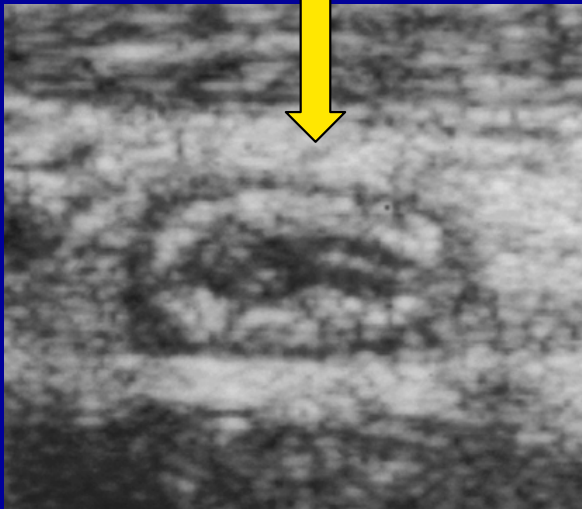
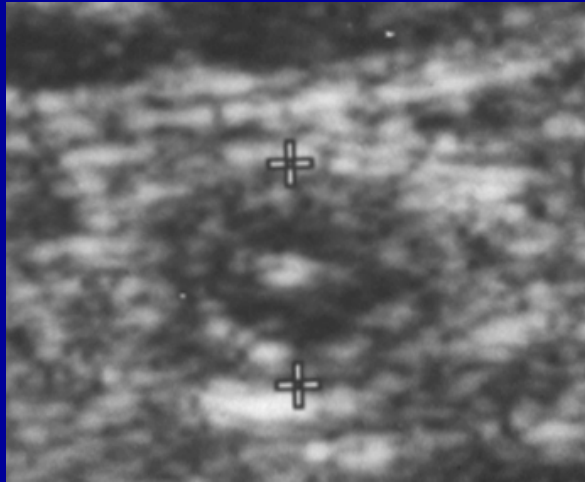
Rettenbacher, Radiology 2011;  
218: 757.

- **7 mm or >**
  - Similar accuracy

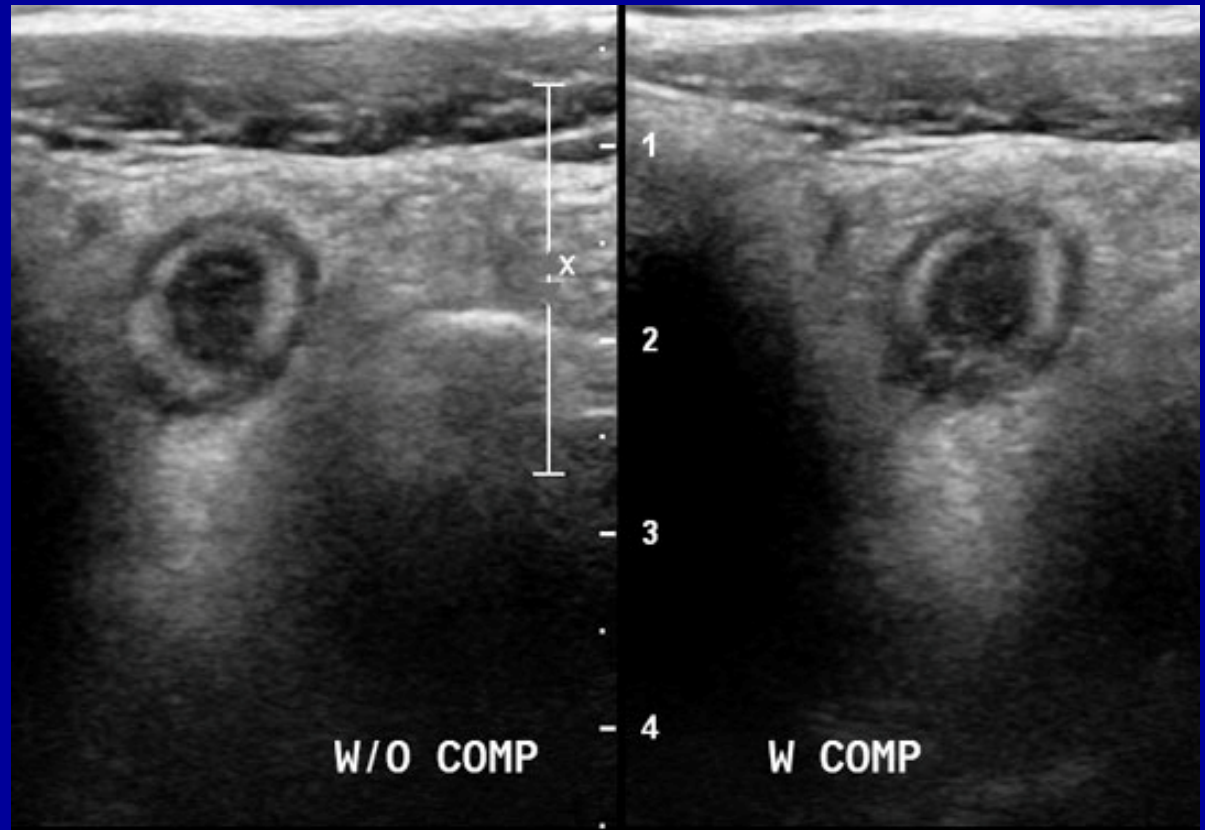
Goldin, Pediatr Radiol 2011; 41:  
993.



# Compressibility – can be difficult to demonstrate with normal appendix



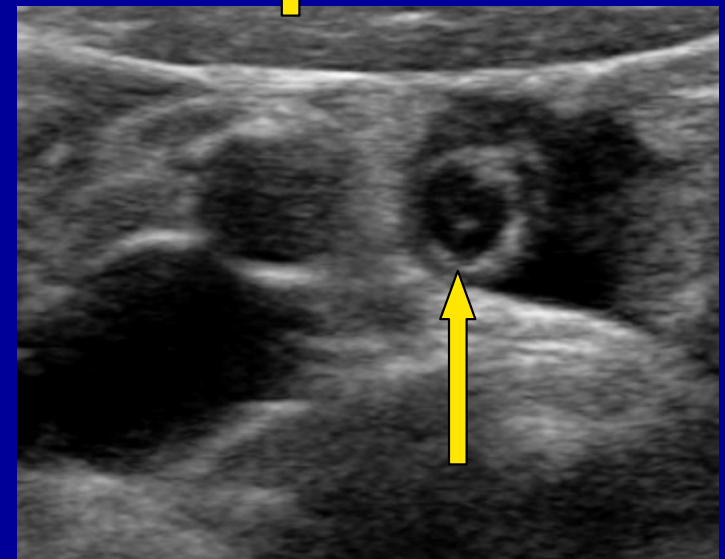
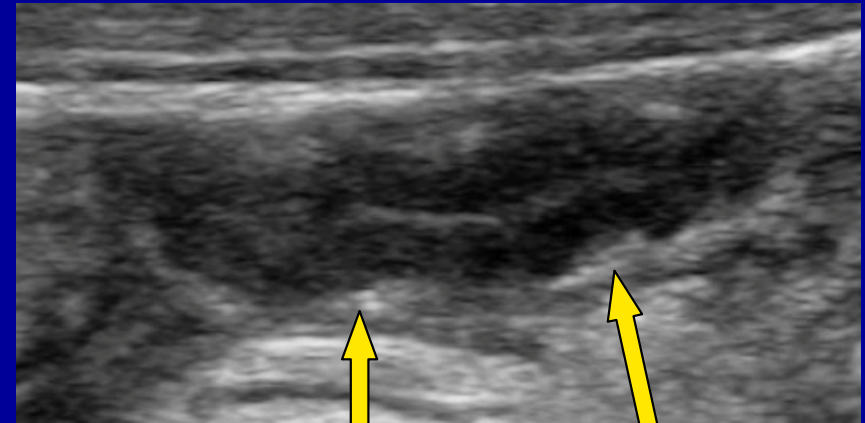
Normal



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

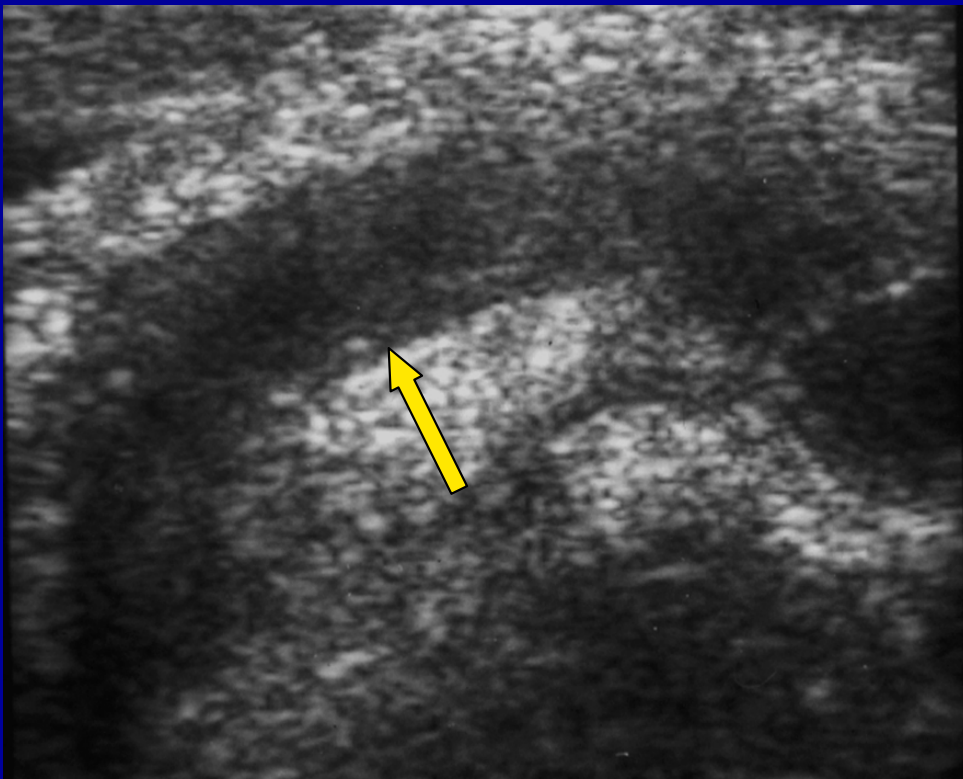
- Dilated small bowel
- RLQ mass
- Colon cut-off
- Flank stripe





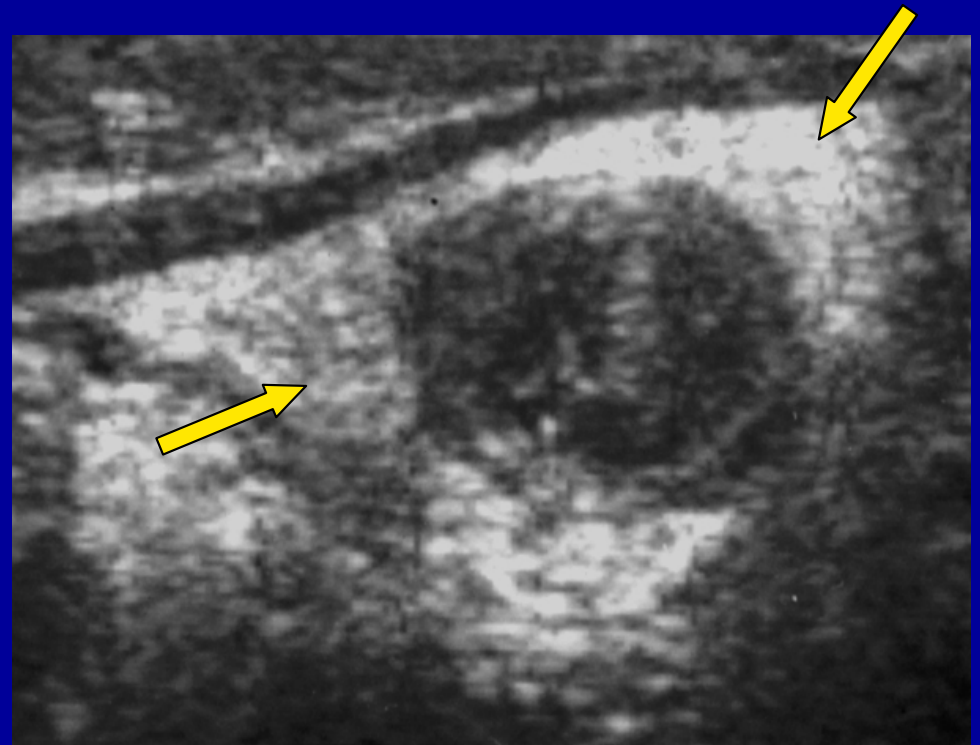
## Signs of Active or Impending Perforation

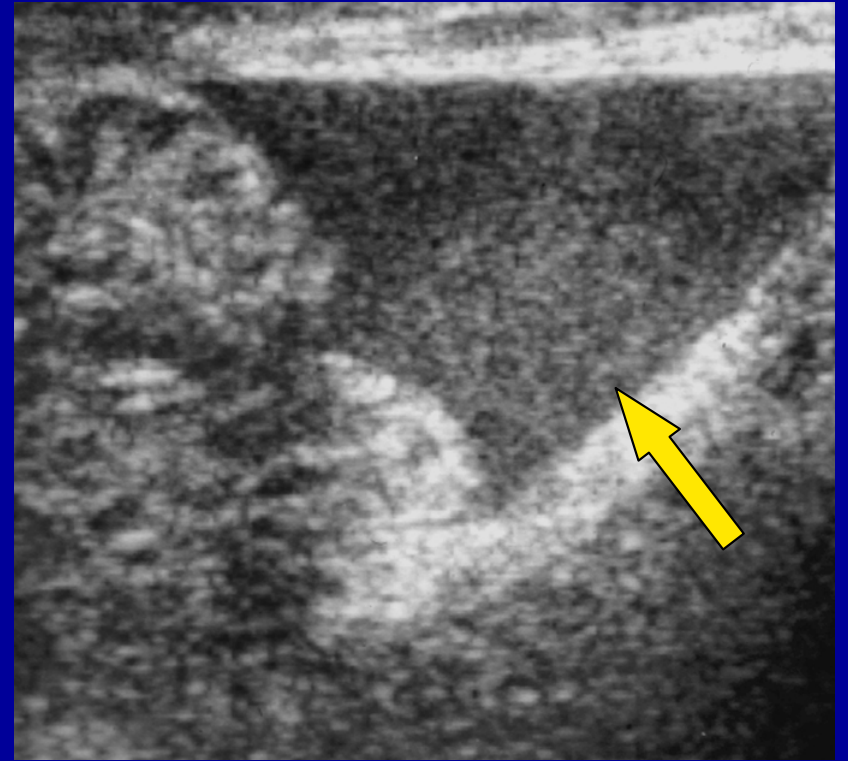
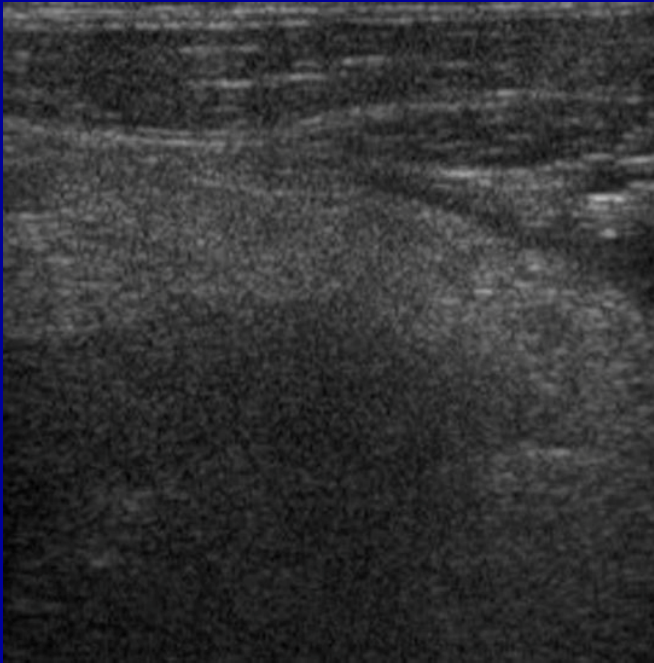
- Loss of mucosal lining
- Edematous fat
- Adjacent fluid collections



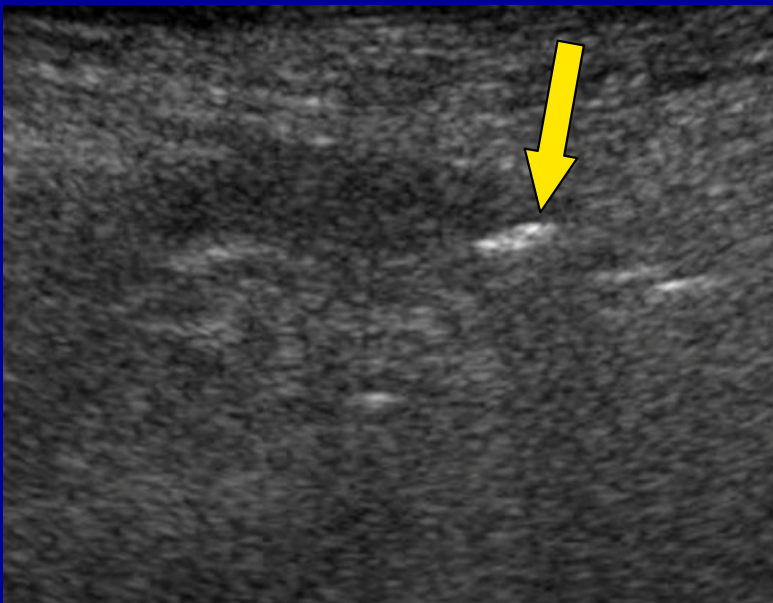
Secondary findings can be strong indicators of appendicitis

Wiersma, Eur Radiol 2009; 19: 455.



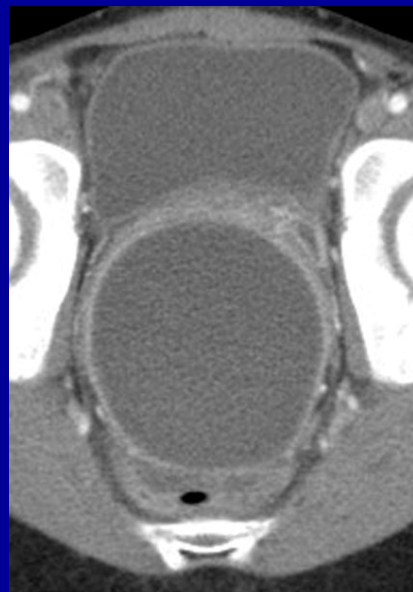
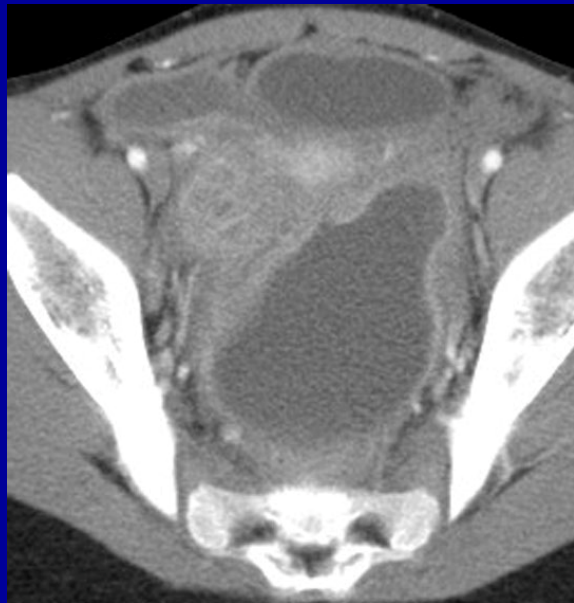
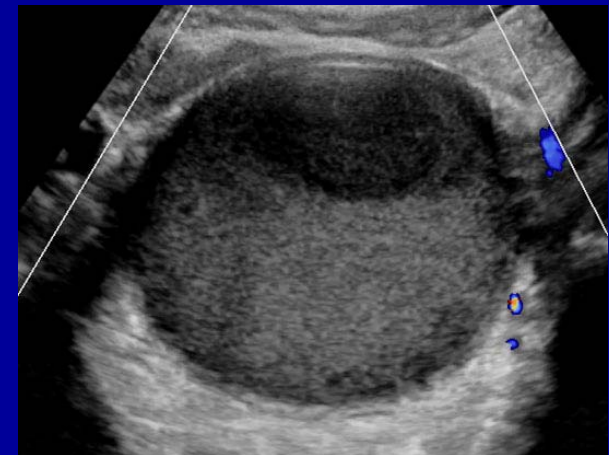
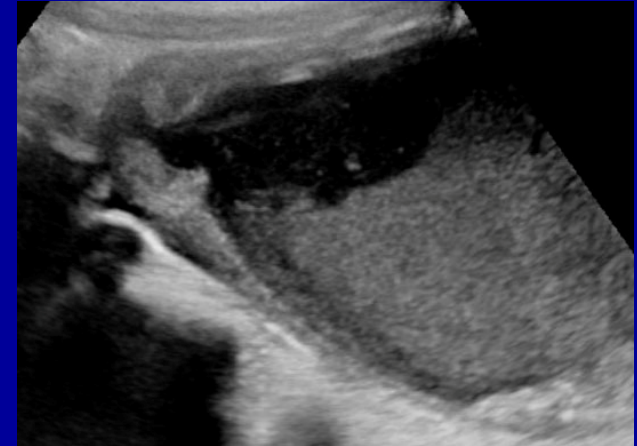
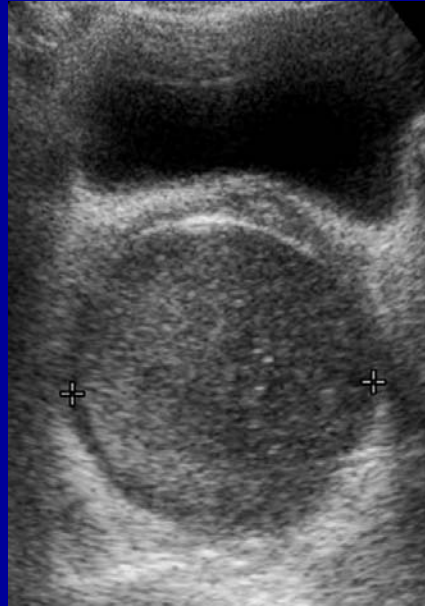
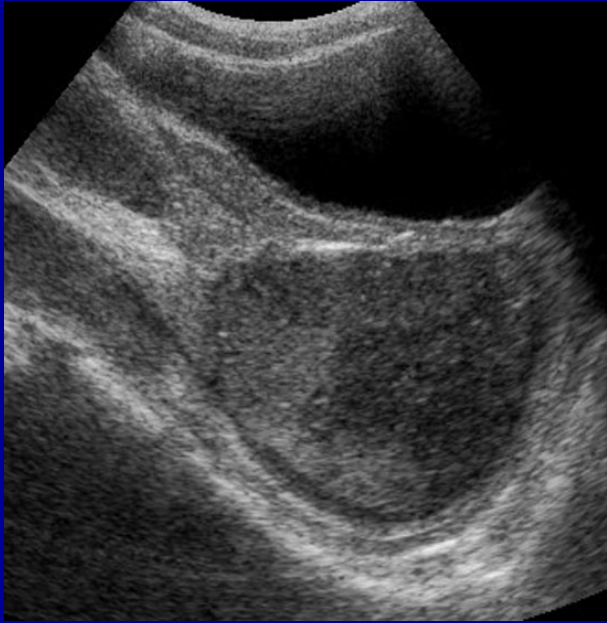


**Complex free fluid = peritonitis**



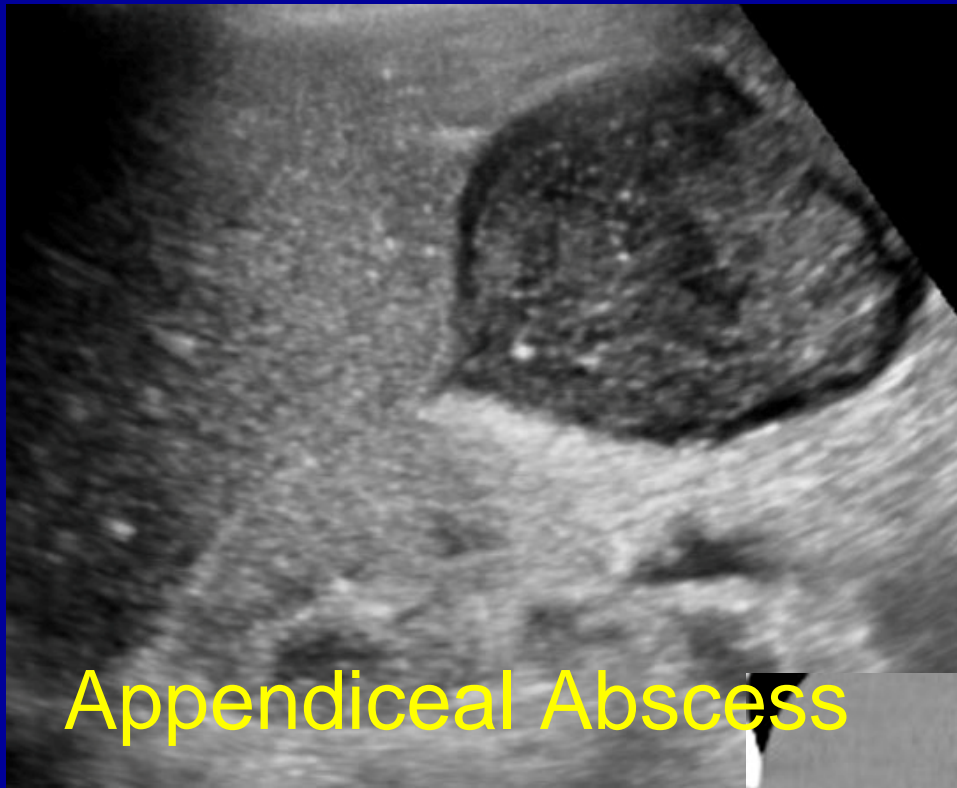
**Thickened Echogenic Fat = Inflammation**

# Abscesses Mimic Other Pathologies

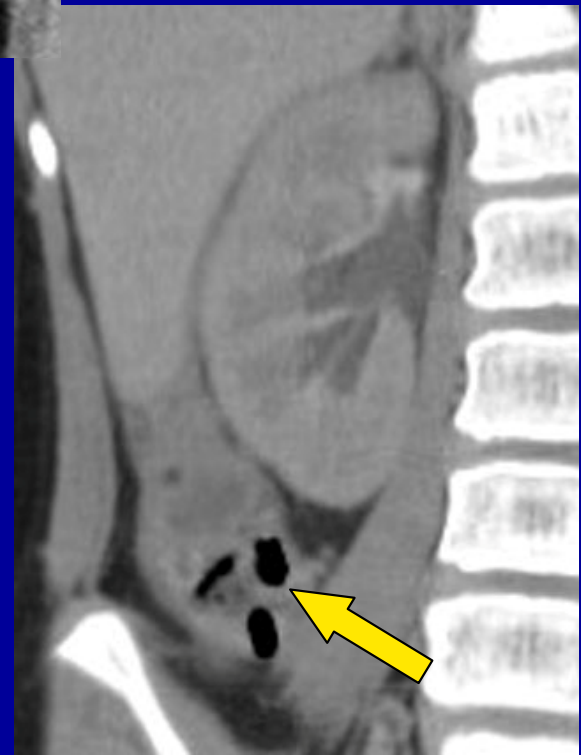
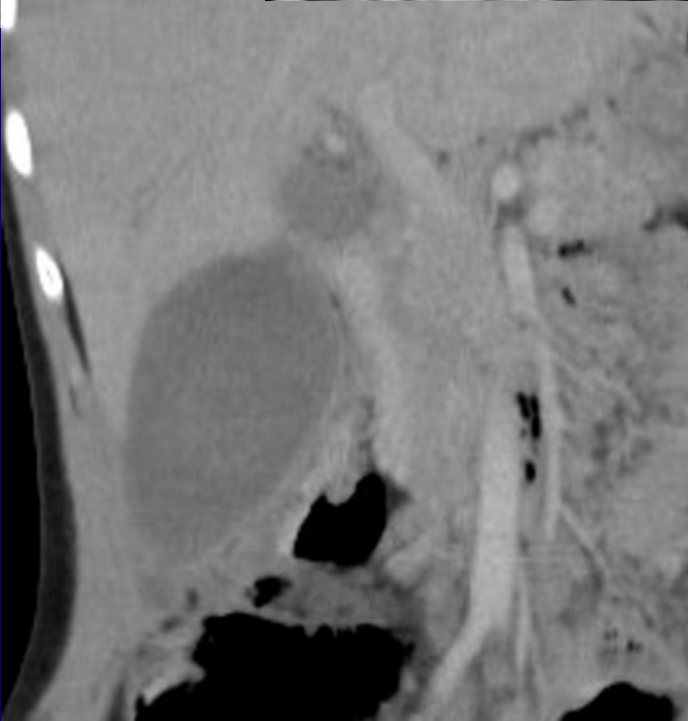
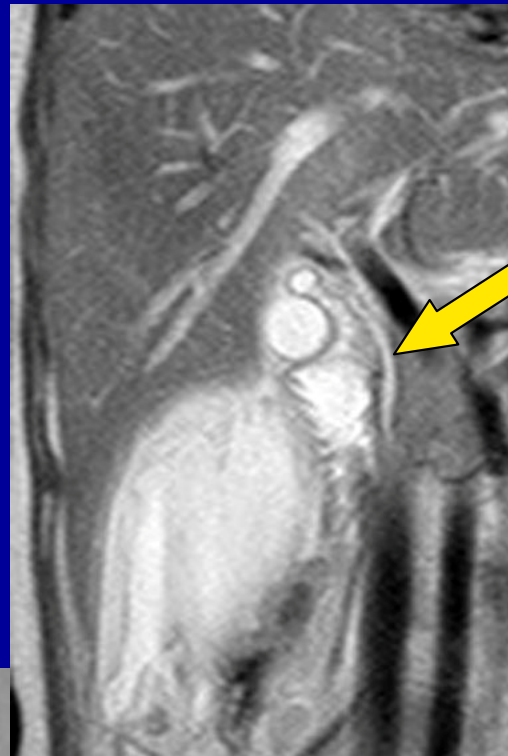


Hematometrocolpos

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**

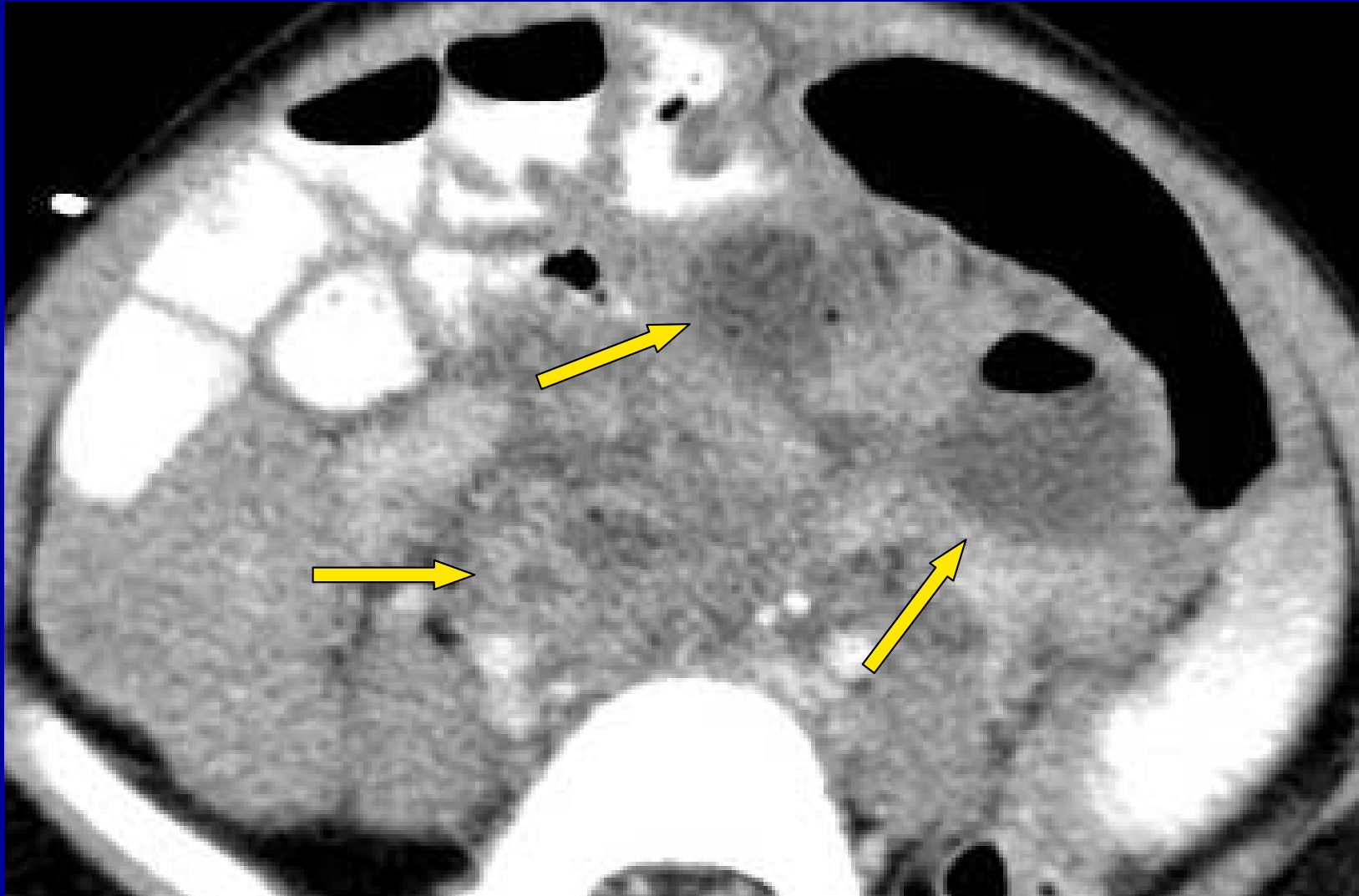
# Advice for Decreasing Dose in Pediatric CT

Goske et al, AJR (2008)

- “Child-size” your CT (kVp, mA)
  - Pediatric protocols on IG website ([www.imagegently.org](http://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

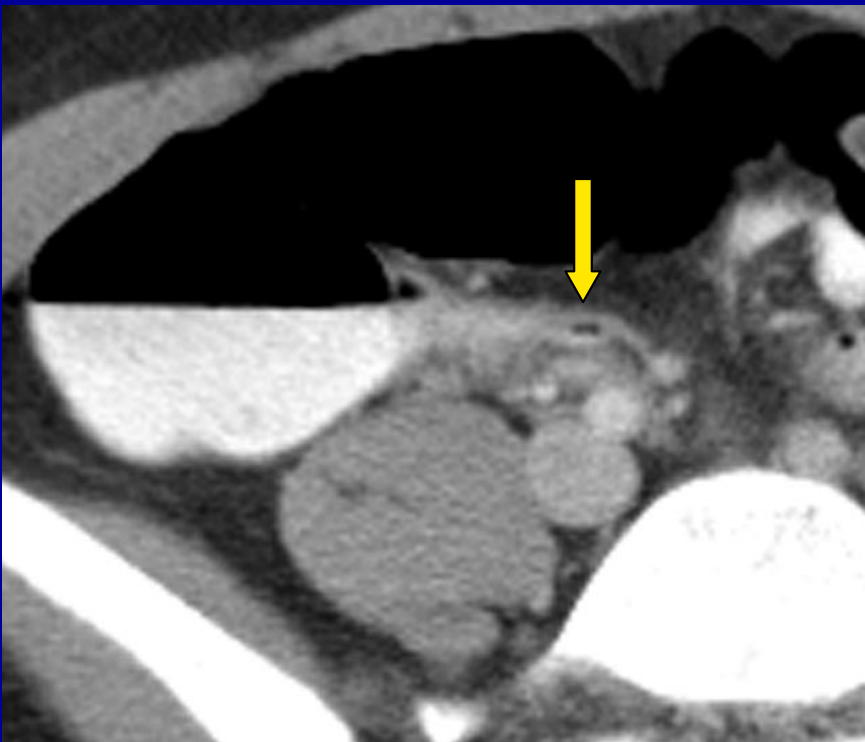
- Lack of intra-abdominal fat







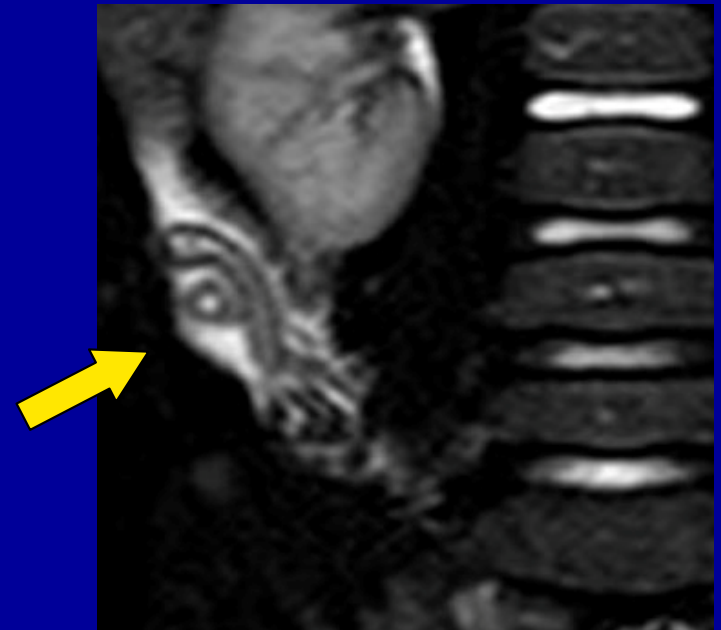
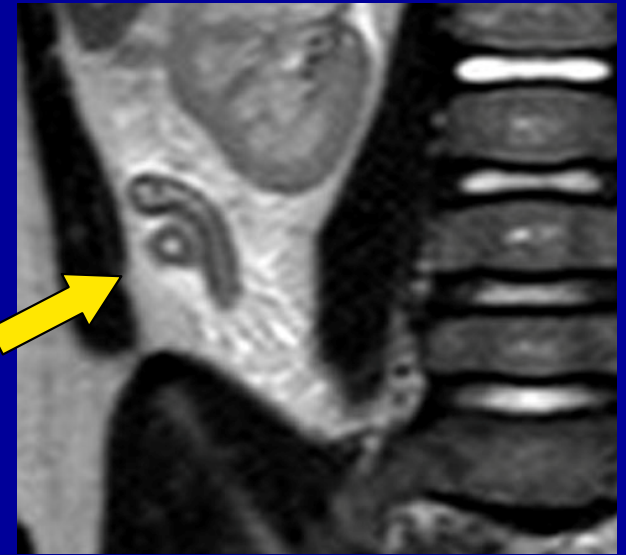
# Planar Reformating



# Ultrafast 3T MRI for Appendicitis

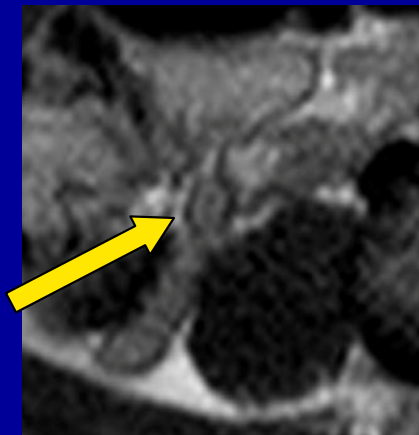
- 42 children
  - Ages 4-17
- No sedation or contrast
- TSE sequences w/wo fat saturation
- Scan times less than 9 minutes
- Normal appendix seen 43% of the time
- Sens/spec 100/99%
  - PPV 98%
  - NPV 100%

Johnson, AJR 2012, Jun 198:1424

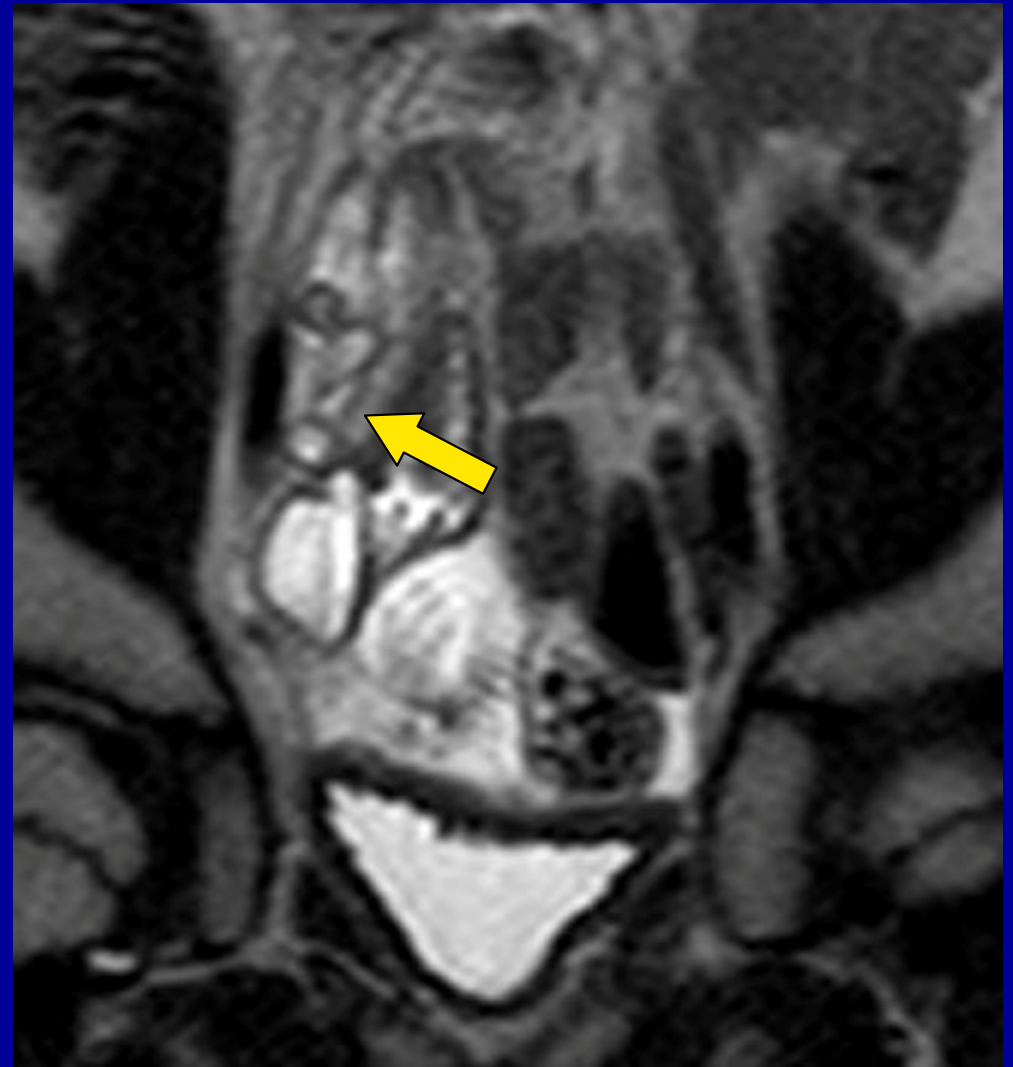
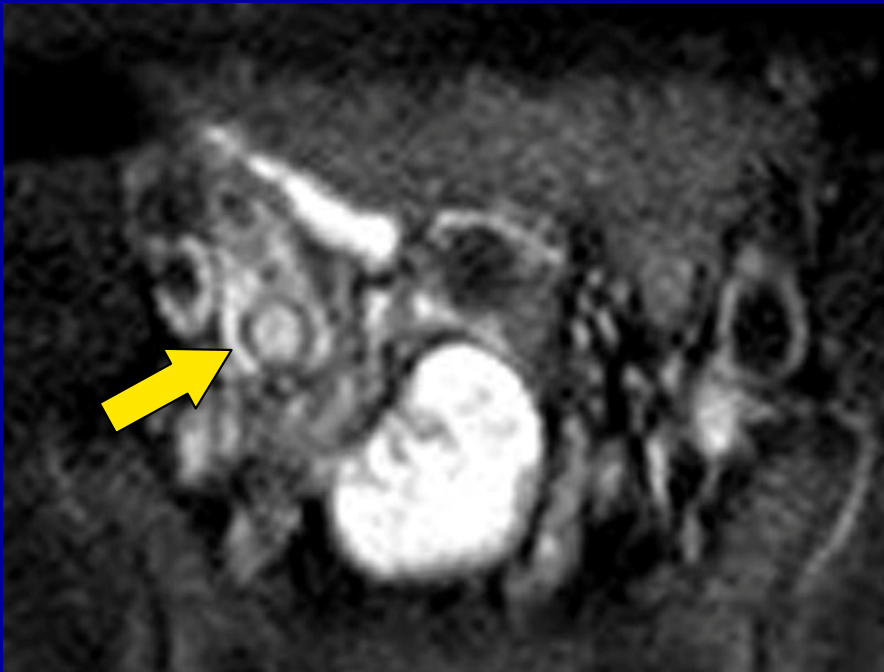


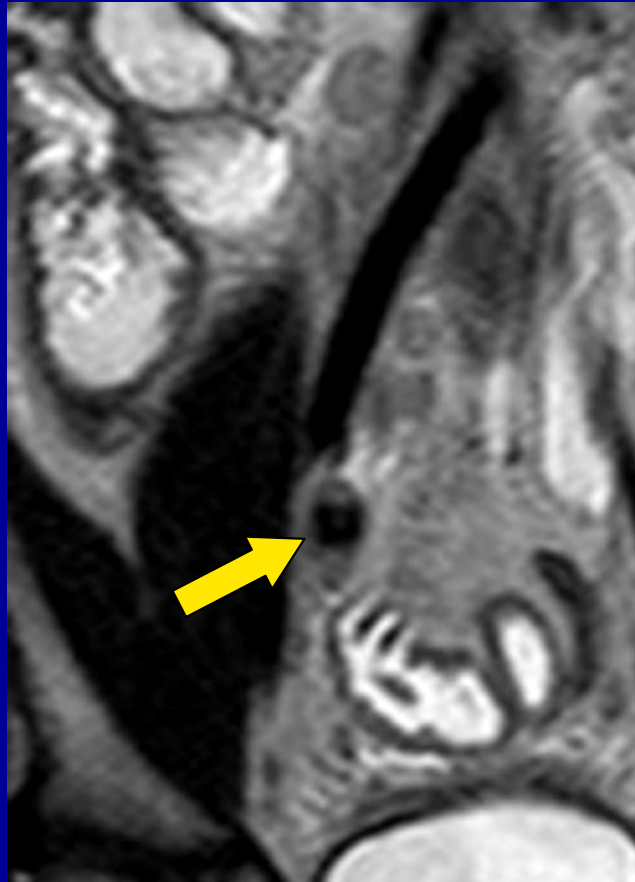
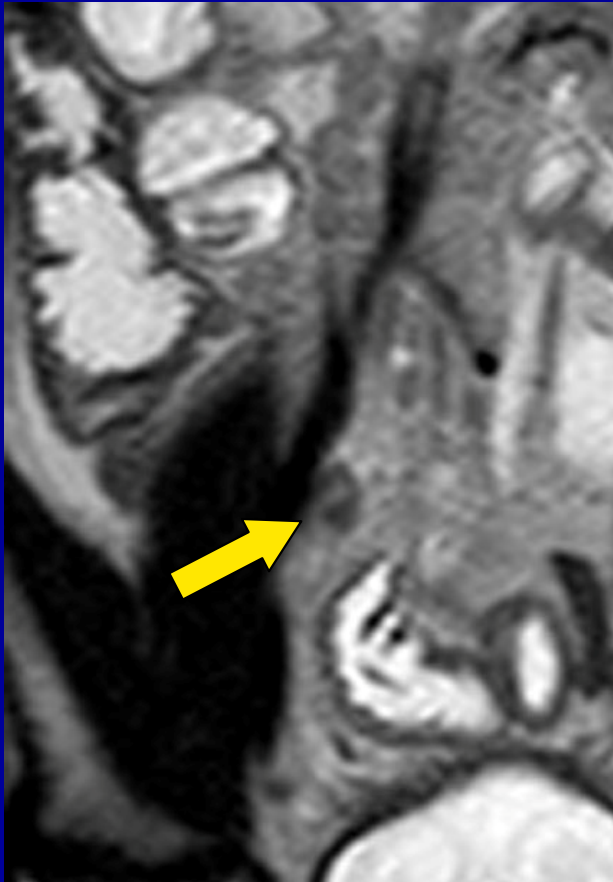
# MRI for Pediatric Appendicitis

- **Moore, Pediatr Radiol, Mar 2012; 42:1056.**
  - 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%



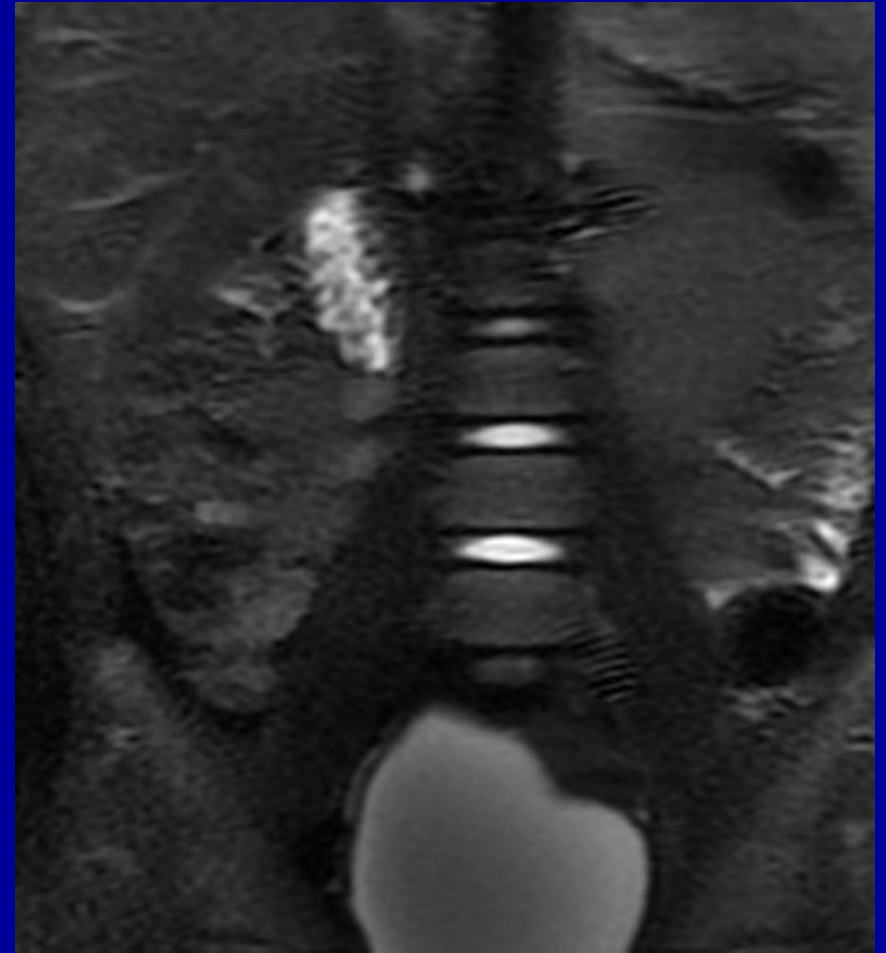
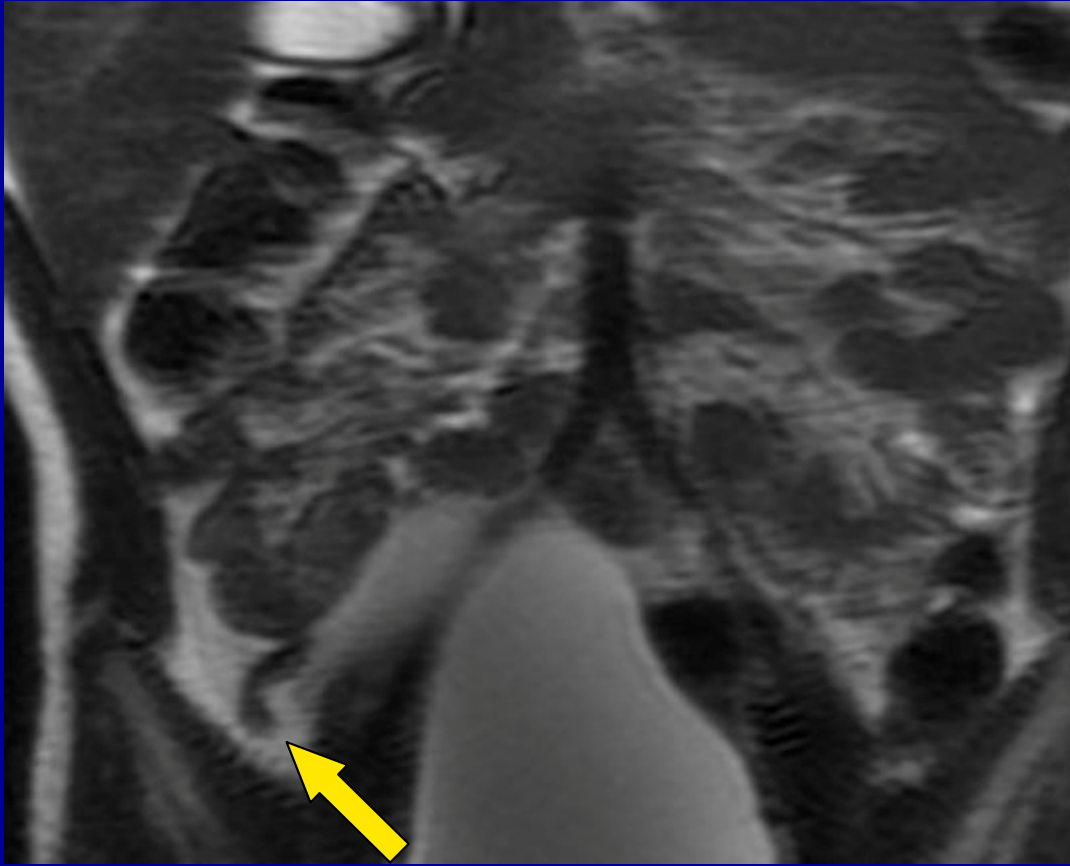
# Appendicitis

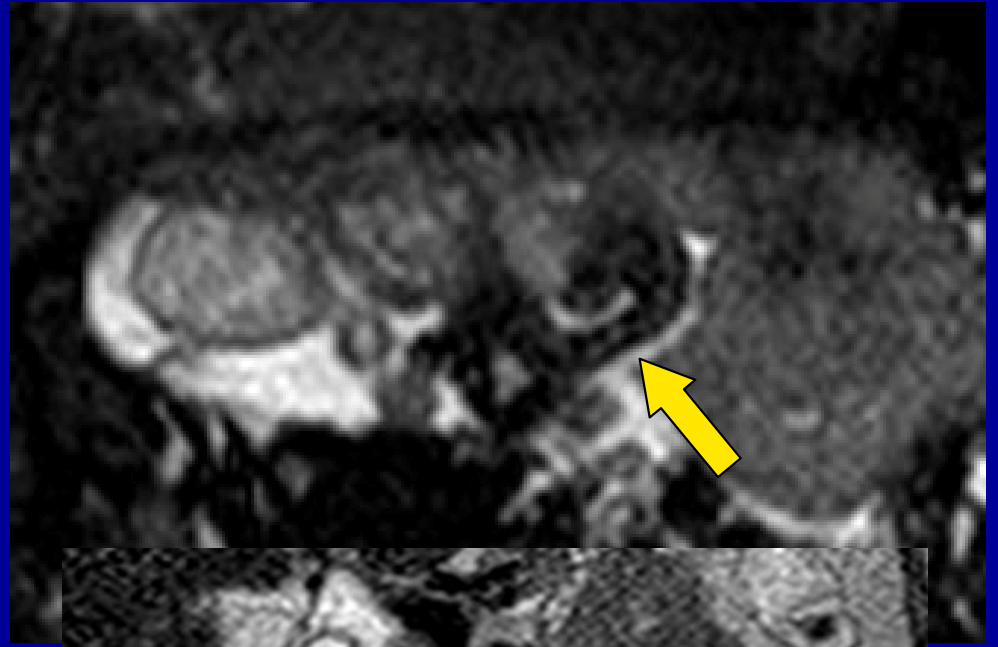
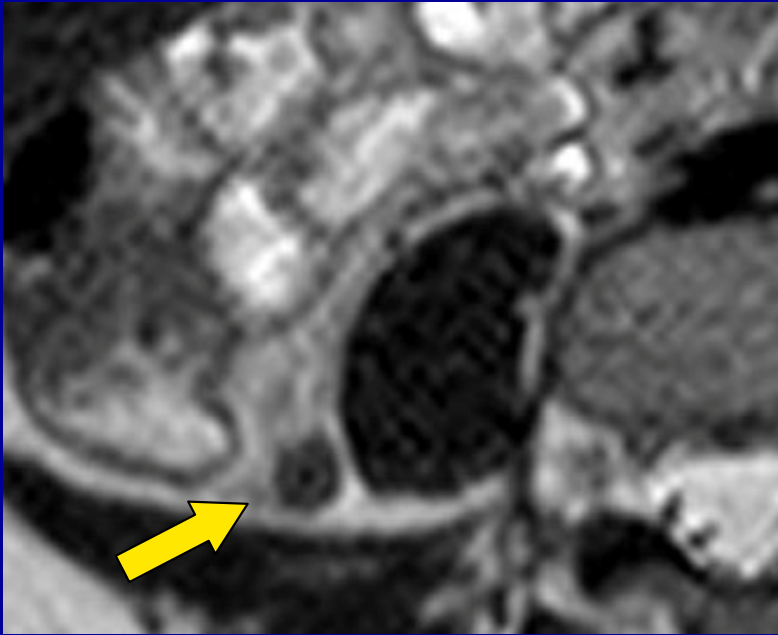




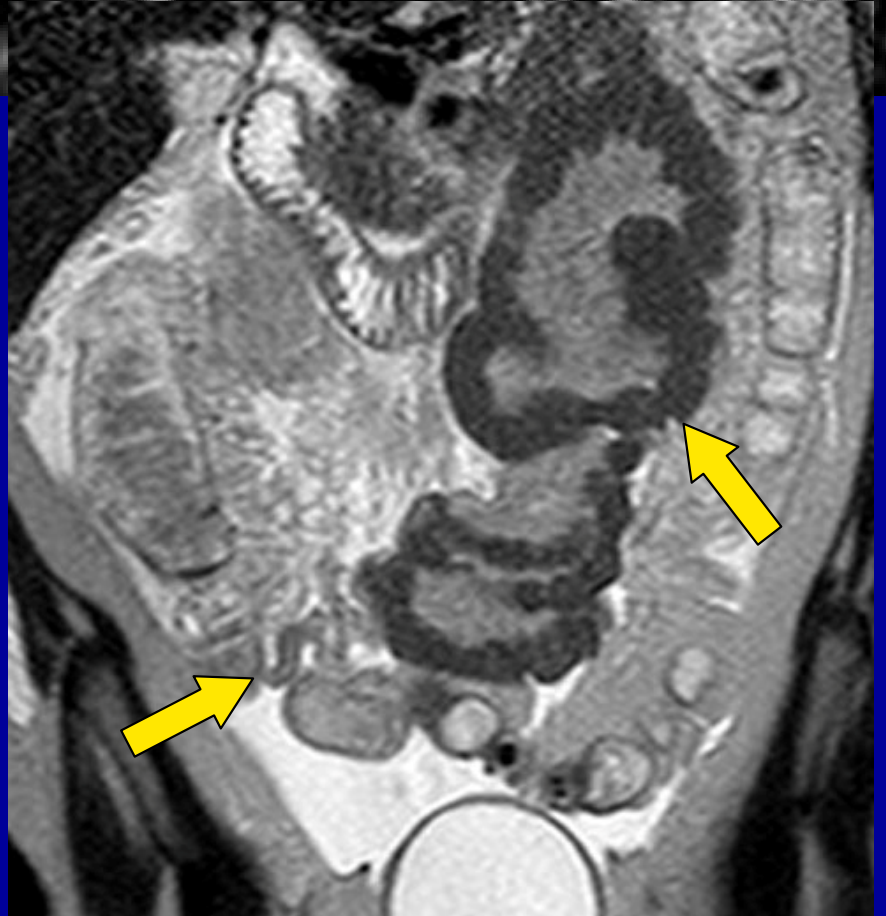
**Calcified appendicolith with distal obstruction**

# 3 yr 11 month old with normal appendix





Normal appendix



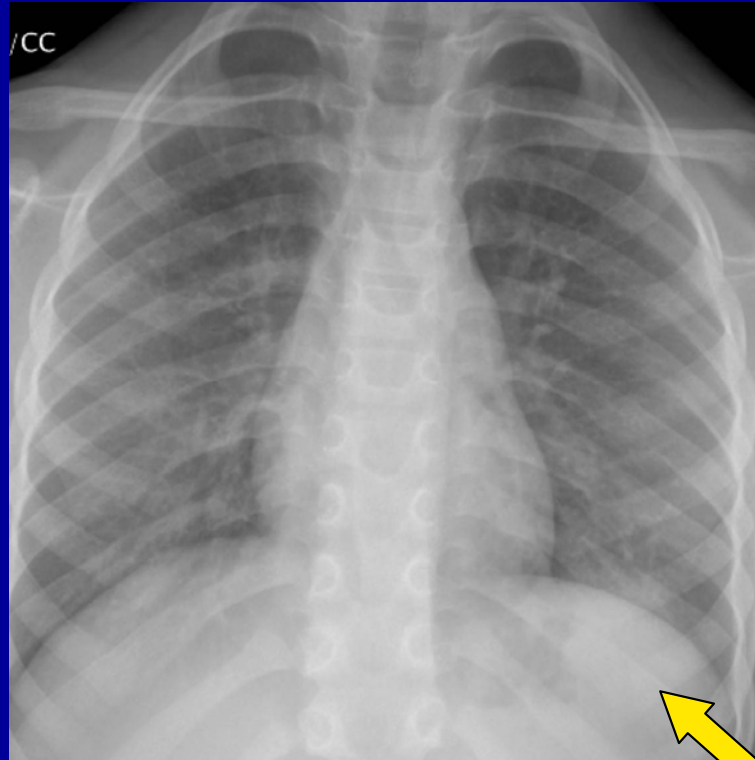
4

## **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

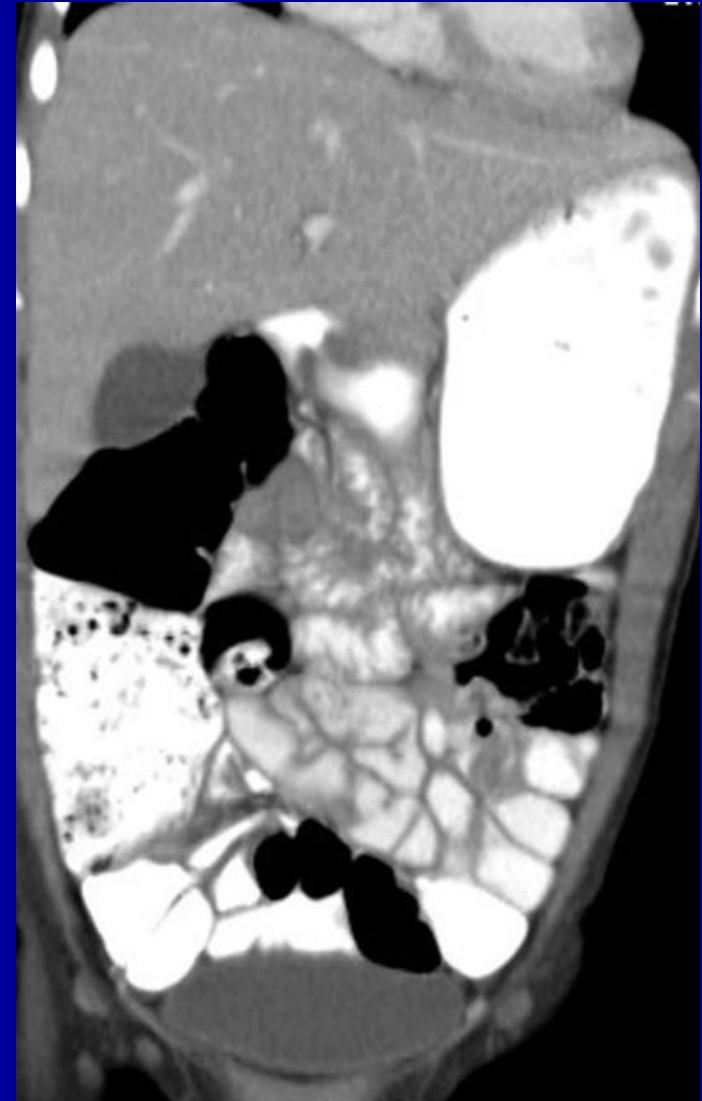


Left Lower Lobe Pneumonia

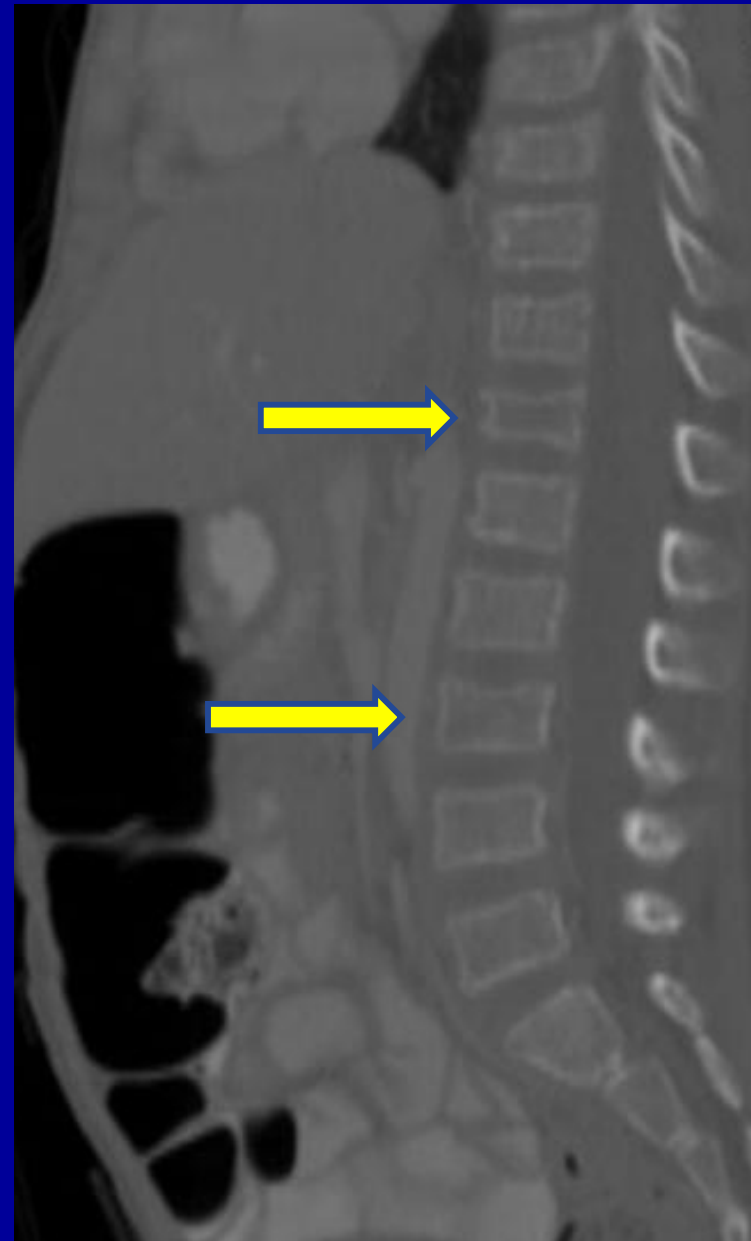
5 yr old with abdominal pain, fever, and vomiting

# 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

[susan.d.john@uth.tmc.edu](mailto:susan.d.john@uth.tmc.edu)