# Common Challenges in Pediatric Emergency Radiology and How to Overcome Them


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Cleveland Clinic Children's

# PRESENTER FINANCIAL DISCLOSURE

I have no financial relationships relevant to this presentation

# Objectives

- Describe common challenges in pediatric emergency imaging and strategies to overcome them

# Non-Interpretive Challenges

# Challenges Related to Patient Age

- Anatomical, physiological, and developmental differences between children and adults, and across the pediatric age range
- Ability to understand, cooperate, and follow command impacts image quality
- Pediatric patients are more vulnerable to effects of ionizing radiation

# Challenges Related to Patient Age

- Practice patience
- Communicate using language appropriate to patient age
- Build trust with patient and family
- Demonstrate empathy

# Tips for Successful Pediatric Imaging

- Engage caregivers
- Allow children to explore
- Distractions: toys, tablets, child-life specialists
- Optimize timing of the study
  - Perform before invasive tests
  - Feed and sleep protocols
- Directly communicate with older kids and adolescents

# Challenges due to Lack of Pediatric Expertise

- Many technologists have limited experience imaging children
- Identify leaders that can champion quality improvement efforts in pediatric imaging
- Offer formal and informal opportunities for learning
- Provide regular feedback

# Challenges due to Lack of Pediatric Expertise

- Referring physician may not be a pediatrician
- Report should clearly convey findings, impression and recommended follow-up when appropriate – be specific!
- Call to discuss critical findings, clarify any need for follow-up

# Challenges Related to Inappropriate Imaging Orders

- Vet orders
- Predefined order sets in EMR
- Algorithms / Clinical Decision Tools
- Guidelines for common conditions

# AI in Pediatric Imaging

- 8/229 AI products are cleared by the FDA for use in pediatric patients
- As of 9/8/2022 all FDA cleared AI triage algorithms are approved only for use in adults
- Lack of transparency

# Diagnostic Challenges

# Work-Up of Appendicitis

- Standardized US reports with interpretive categories better convey diagnostic certainty, increase diagnostic accuracy, and decrease CT utilization
  - 1: normal appendix
  - 2: appendix not visualized, no secondary signs of appendicitis
  - 3: appendix not visualized, positive secondary signs of appendicitis
  - 4: equivocal
  - 5: appendicitis
- Should be data driven and dependent on available resources and expertise

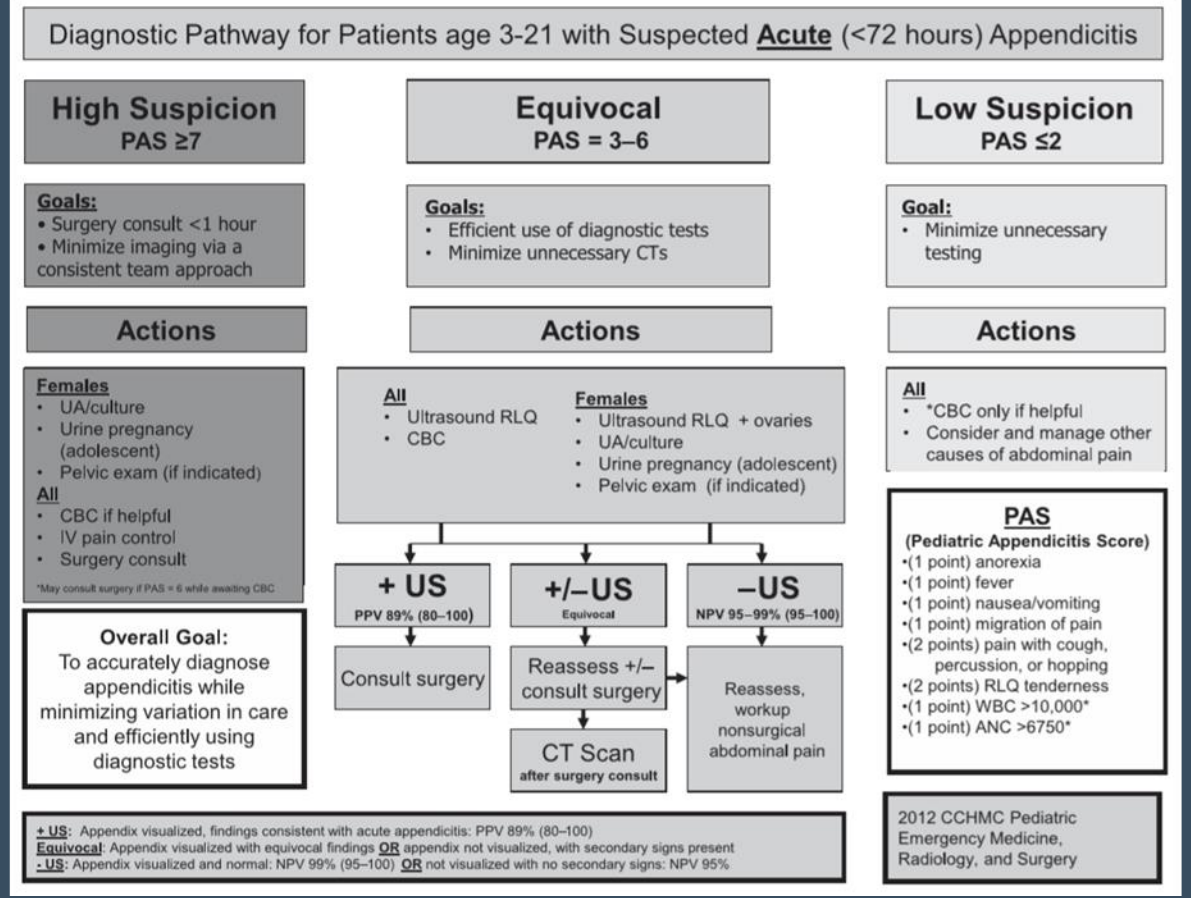
Larson DB, Trout AT, Fierke SR, Towbin AJ. Improvement in diagnostic accuracy of ultrasound of the pediatric appendix through the use of equivocal interpretive categories. American Journal of Roentgenology. 2015 Apr;204(4):849-56.

Fallon SC, Orth RC, Guillerman RP, Munden MM, Zhang W, Elder SC, Cruz AT, Brandt ML, Lopez ME, Bisset GS. Development and validation of an ultrasound scoring system for children with suspected acute appendicitis. Pediatric radiology. 2015 Dec;45:1945-52.

# Clinical Decision Support Tools

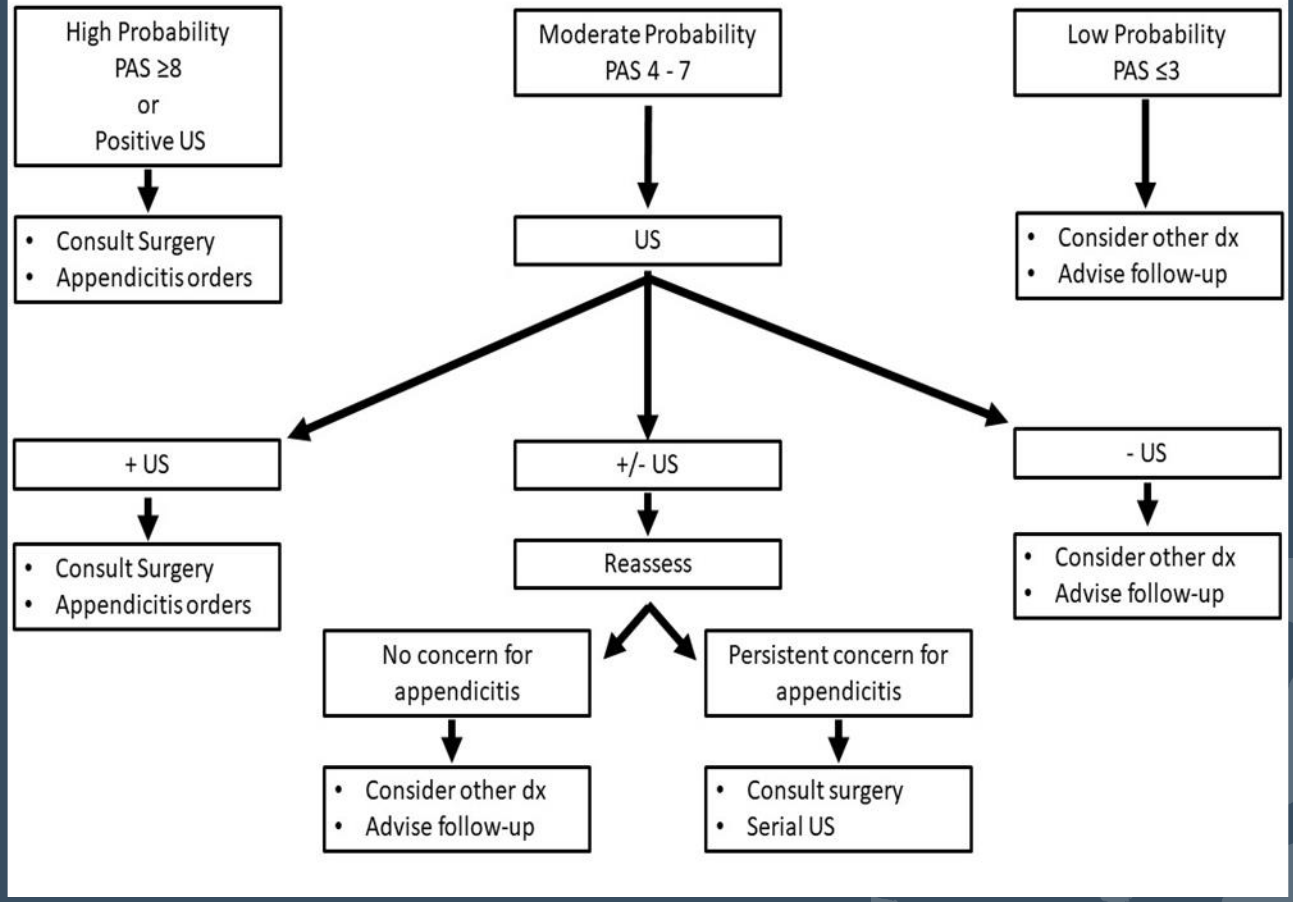
Cincinnati Children's
changing the outcome together

Depinet H, von Allmen D, Towbin A, Hornung R, Ho M, Alessandrini E. Risk stratification to decrease unnecessary diagnostic imaging for acute appendicitis. Pediatrics. 2016 Sep 1;138(3):e20154031.




SickKids®

Schuh S, Chan K, Langer JC, Kulik D, Preto-Zamperlini M, Aswad NA, Man C, Mohanta A, Stephens D, Doria AS. Properties of serial ultrasound clinical diagnostic pathway in suspected appendicitis and related computed tomography use. Academic Emergency Medicine. 2015 Apr 1;22(4):406-14.



# CCF Pathway for Management of Pediatric Patients (<18 y/o) with Right Lower Quadrant Pain and Suspected Appendicitis in the ED*

Overall goals: Minimize CT use, Improve diagnostic accuracy, Improve specificity of surgical consult

*Note that RLQ US for pediatrics is only performed at Hub Hospitals- Main Campus, Fairview, Hillcrest,*

***If patient presents to non-hub site, goal is quick exam by attending and prompt transfer by private car as indicated if PAS >3 *and stable*. Do not delay transfer to get IV, labs or IV meds.**

## High Suspicion
PAS ≥ 7

### Actions

**Females**
Consider pelvic etiology
- UA/culture
- Urine pregnancy (adolescent)
- Pelvic exam (if indicated +/- US)

**All***
- CBC (CRP not needed)
- IV pain control
- RLQ ultrasound

### US Results

- **Grade 4** Positive for appendicitis, appendix visualized → Admit to peds** (with surgical consult)
- **Grade 3** No appendix seen but Positive for secondary signs → Consider CT vs admit **TO PEDS** for serial exams and repeat US in 8 hours after Pt centered discussion
- **Grade 2** No appendix seen and no secondary signs → Consider CT vs admit **TO PEDS** for serial exams and repeat US in 8 hours after Pt centered discussion
- **Grade 1** Appendix visualized and appears normal → Consider alternative diagnosis and admission to **PEDS** for serial exams/repeat US in 8 hours vs DC home with close peds or ED follow-up

## Equivocal
PAS = 3 - 6

### Actions

**Females**
- Ultrasound RLQ + ovaries (if indicated)
- UA/culture
- Urine pregnancy (adolescent)
- Pelvic exam (if indicated)

**All***
- CBC (CRP not needed)
- RLQ ultrasound

### US Results

- **Grade 4** Positive for appendicitis, appendix visualized → Admit to peds** (with surgical consult)
- **Grade 3** No appendix seen but Positive for secondary signs → Consider CT vs admit **TO PEDS** for serial exams and repeat US in 8 hours after Pt centered discussion
- **Grade 2** No appendix seen and no secondary signs → Reevaluate patient → If better, DC with strict return precautions (return to ED if reoccurs <12); If still tender, admit to peds for pain control and repeat US in 8 hours
- **Grade 1** Appendix visualized and appears normal → Reassess and workup for non-surgical abdominal pain/ DC home

## Low Suspicion
PAS ≤ 2

### Actions

**All***
- CBC only if helpful (CRP not needed)
- RLQ US Generally not needed
- Consider and manage other causes of abdominal pain

### PAS: Pediatric Appendicitis Score

| | |
|---|---|
| **1 point** | Anorexia |
| **1 point** | Fever |
| **1 point** | Nausea/vomiting |
| **1 point** | Migration of pain |
| **2 points** | Pain w/ cough, percussion or hopping |
| **2 points** | RLQ tenderness |
| **1 point** | WBC > 10,000 |
| **1 point** | ANC > 6,750 |

**** -Antibiotics ONLY if Grade 4 AND WBC >10K. Otherwise defer to/discuss with hospital medicine team. Zosyn - 1st line. If PCN- allergic <10 y/o -meropenem, >10 y/o- Cipro/Flagyl**
**-No surgery consult unless Grade 4 or Grade 3 with high PAS**

Special thanks to:
Brett H Adler, MD
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Brad Sobolewski, MD, Med

Rev 11-2-18

# Clinical Decision Support Tools

## Emergency Department Clinical Pathway for Evaluation/Treatment of Children with Suspected Appendicitis

Goals and Metrics

Provider Resources

**Related Pathway**
Appendicitis, Inpatient

Child with Suspected Appendicitis

Triage

FLOC/RN Team Assessment
History & Physical Examination
Review
- Pediatric Appendicitis Score
- Pediatric Appendicitis Risk Calculator pARC

Low Probability for Appendicitis

Reassuring H&P
Able to tolerate PO
Alternative diagnosis probable
Labs as indicated
Treat as clinically indicated
Discharge, follow-up

Appendicitis: High Probability
Classic features of appendicitis

Obtain Laboratory Studies
CBC, CRP, UA POC, BMP
Urine HCG as clinically indicated
NPO, IVF, analgesia as indicated

Appendicitis: Equivocal
Some features of appendicitis

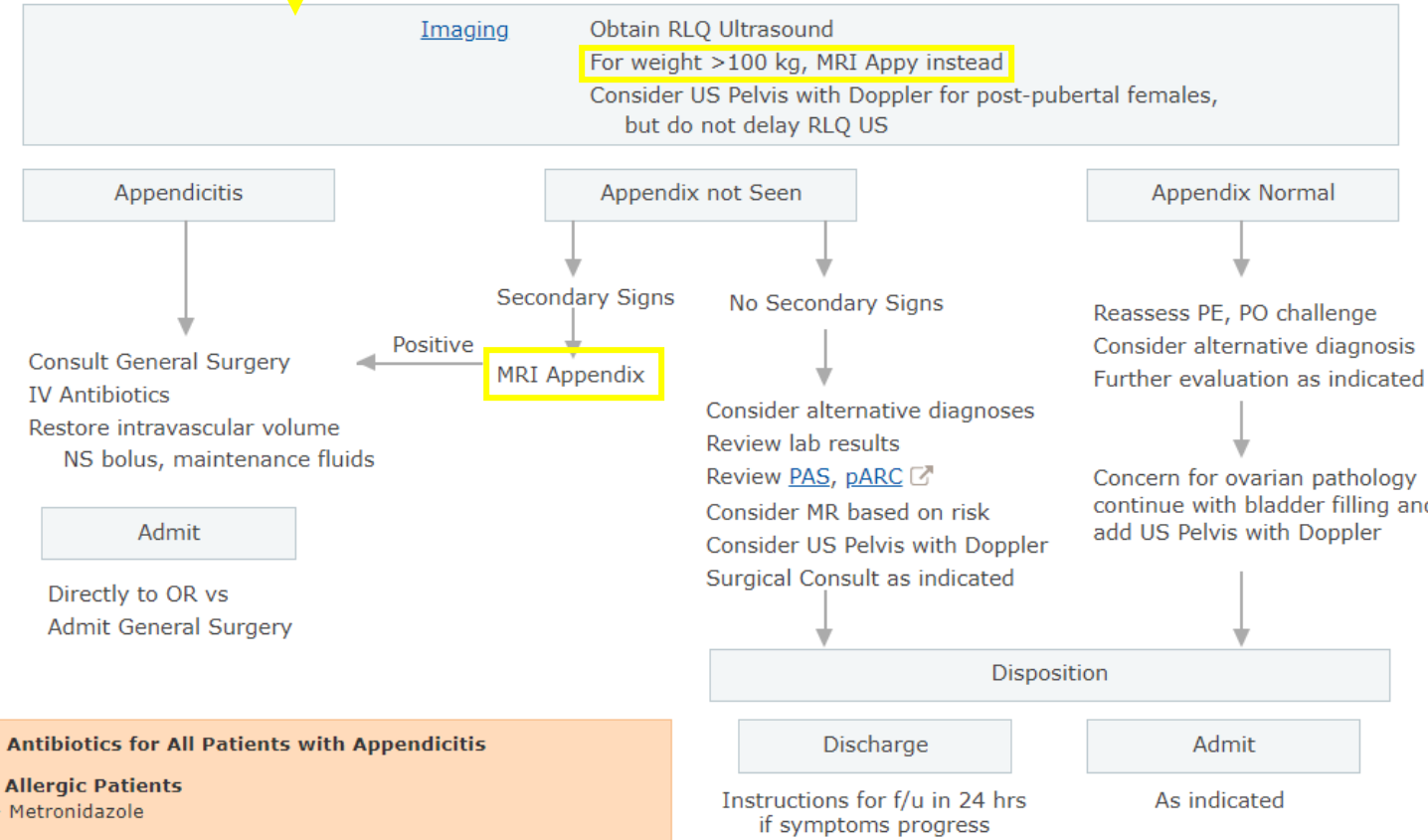
Males, Pre-Pubertal Females

Consider Laboratory Studies
CBC, CRP, UA POC, BMP
IVF, analgesia as indicated

Post-Pubertal Females

Consider Laboratory Studies
CBC, CRP, BMP, serum HCG, UA POC
NPO, IVF, analgesia as indicated
Instruct patient not to urinate
Consider STI testing

https://www.chop.edu/clinical-pathway/appendicitis-emergency-department-clinical-pathway




**Pre-Operative Antibiotics for All Patients with Appendicitis**

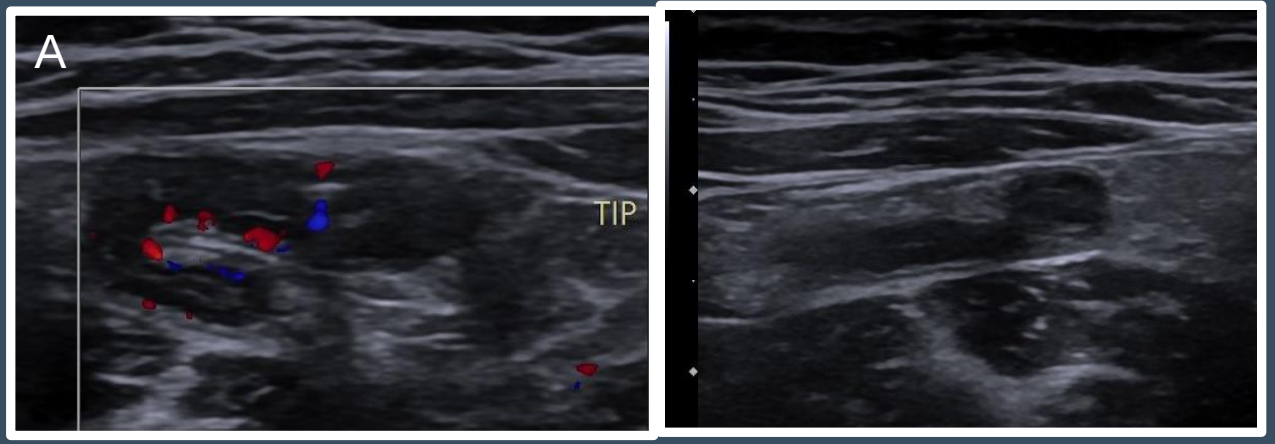
**Healthy, Non- Allergic Patients**
Ceftriaxone + Metronidazole

**Cephalosporin Allergy**
Ciprofloxacin + Metronidazole

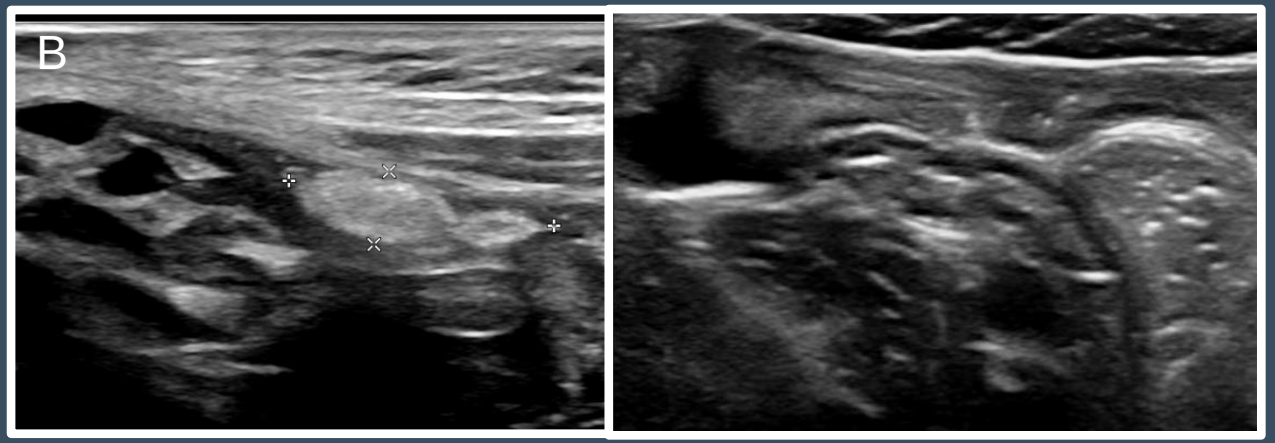
**Ill-appearing, Immunocompromised, or Recent Hospitalization > 4 days**
Piperacillin-tazobactam
Consult ID

**Posted:** October 2006
**Revised:** December 2021
**Authors:** J. Lavelle, MD; J. Collins, MD; S. Kaplan, MD; B. Ku, MD; C. Jacobstein, MD; M. Mittal, MD; M. Joffe, MD; J. Zorc, MD; M. Nance, MD;

# Appendicitis Mimics

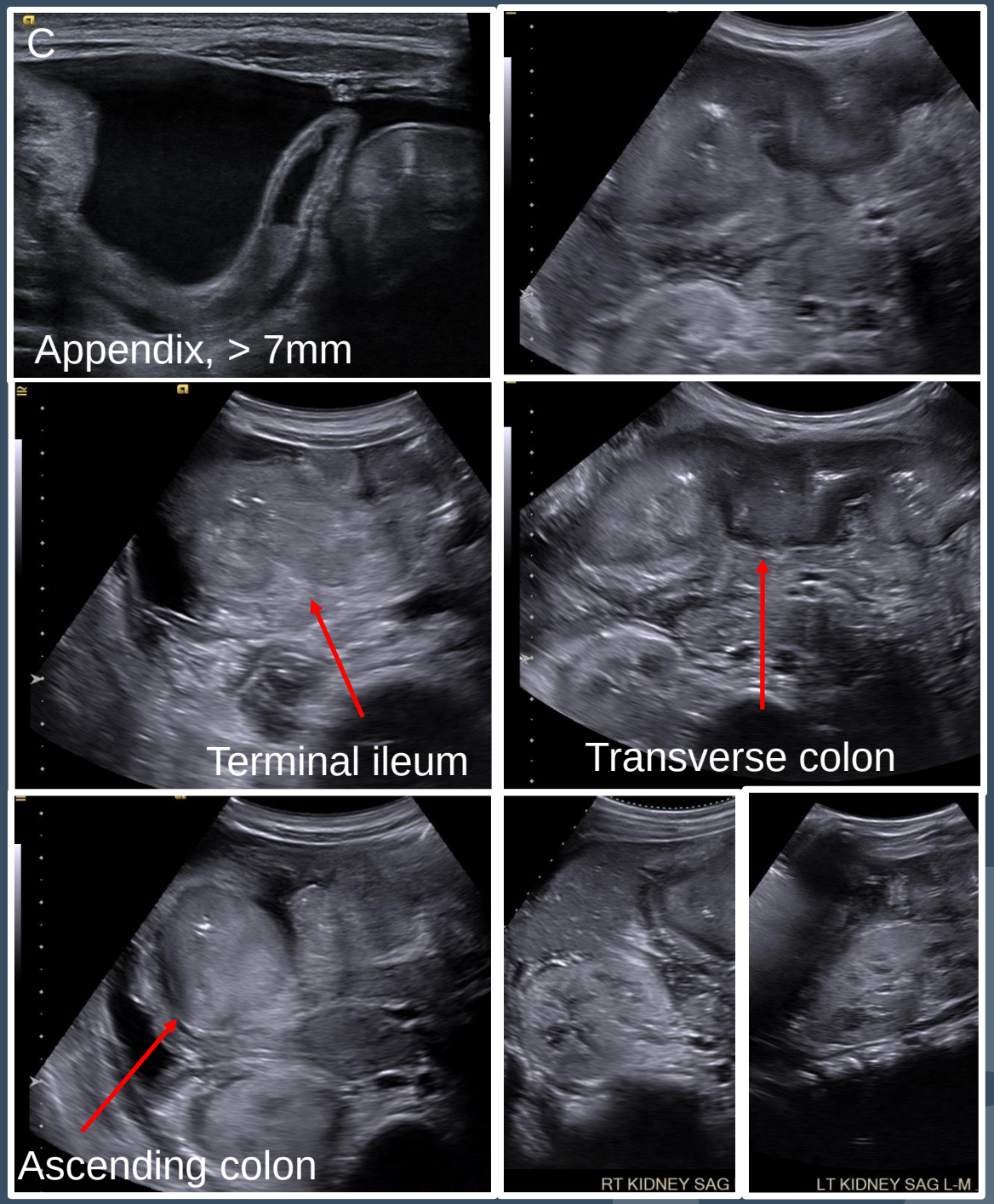



Diagnosis:
Lymphoid hyperplasia

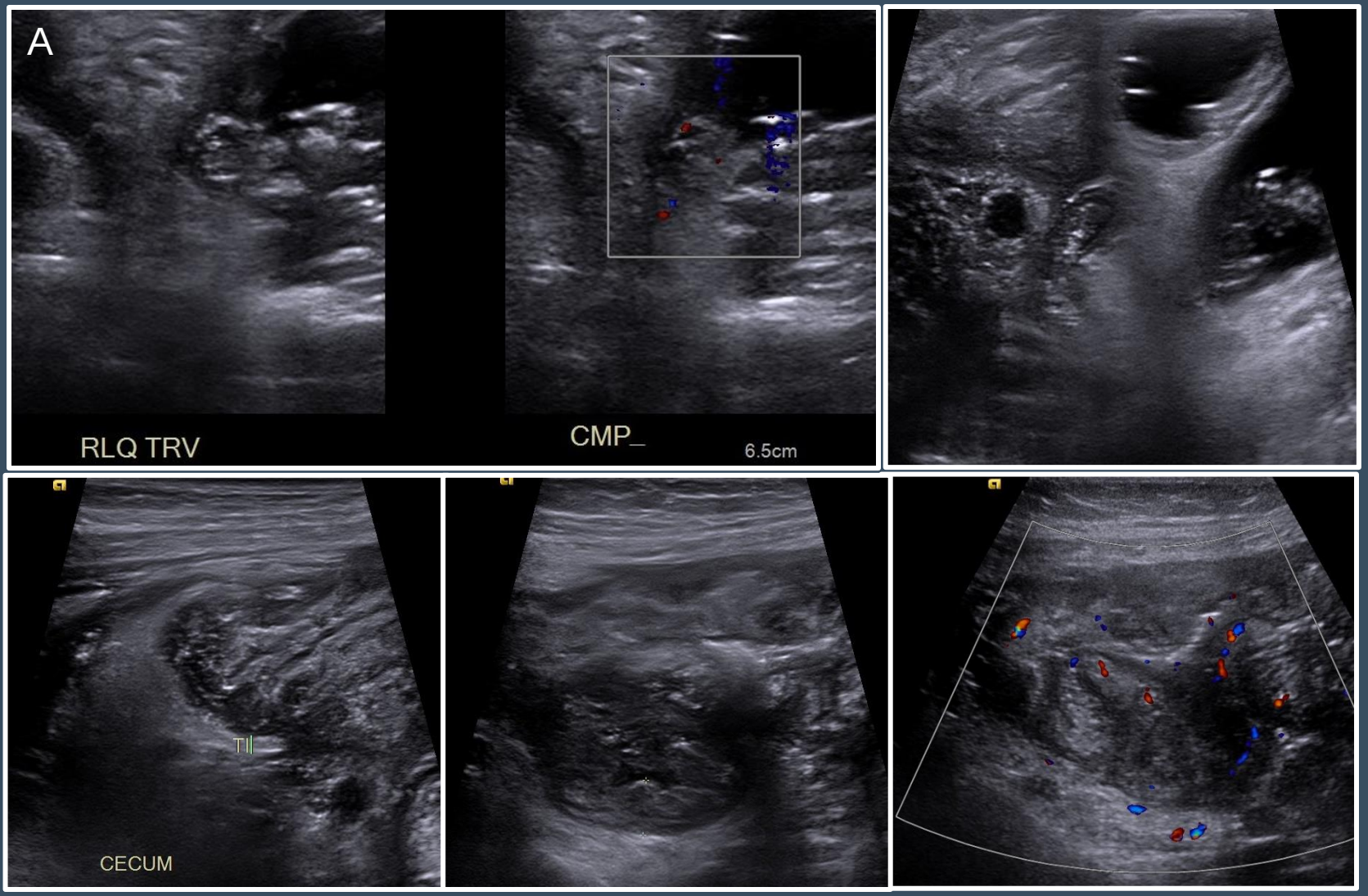



Diagnosis:
Omental infarct

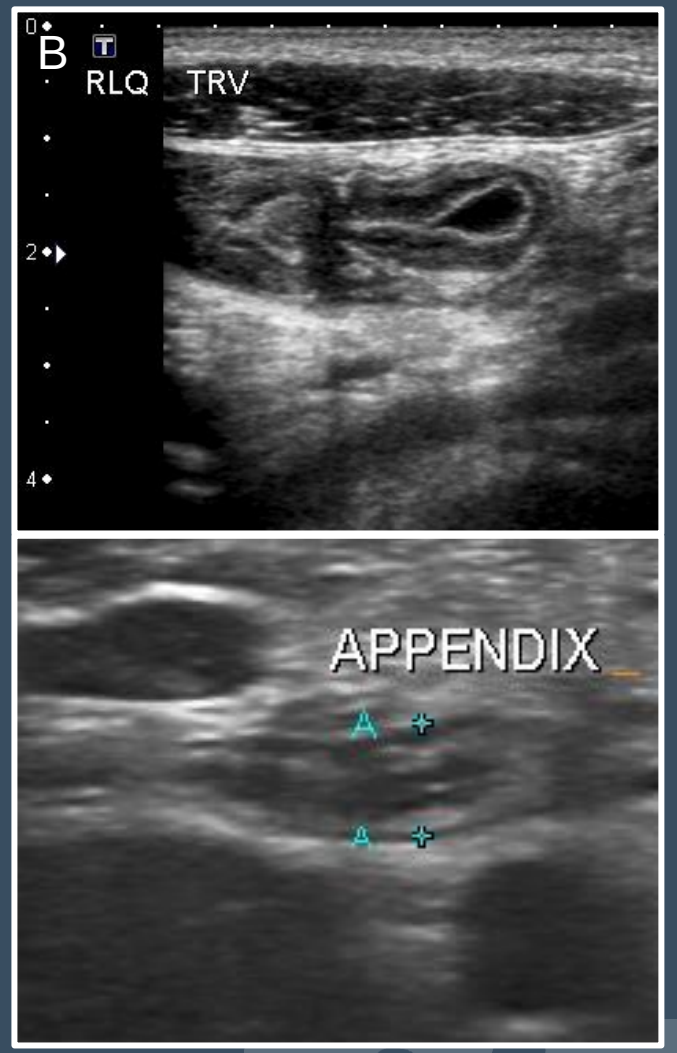
Diagnosis:
Hemolytic uremic syndrome



# Appendicitis Mimics




Diagnosis:
Inflammatory bowel disease



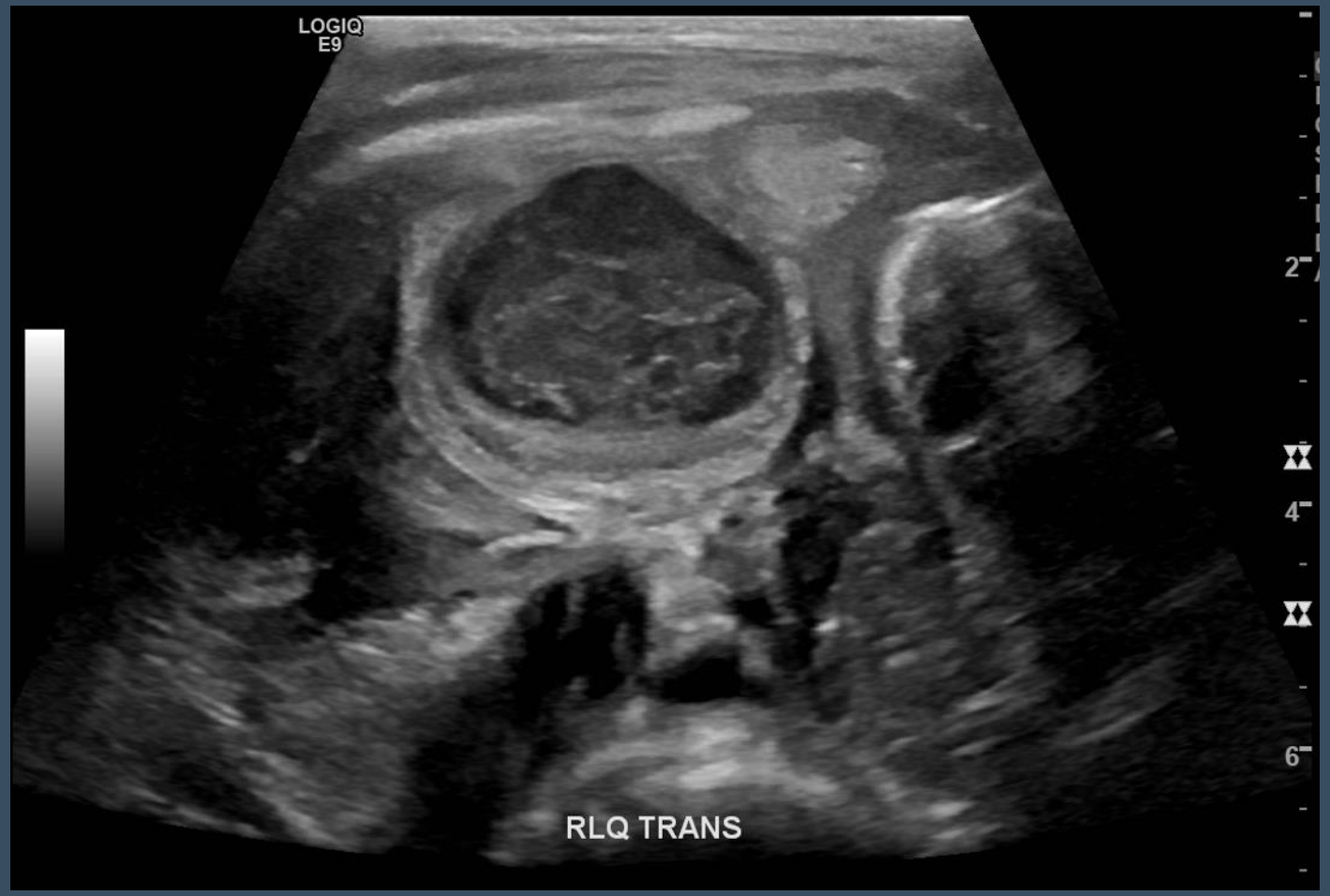

Diagnosis:
Meckel diverticulitis

**Teaching Point**

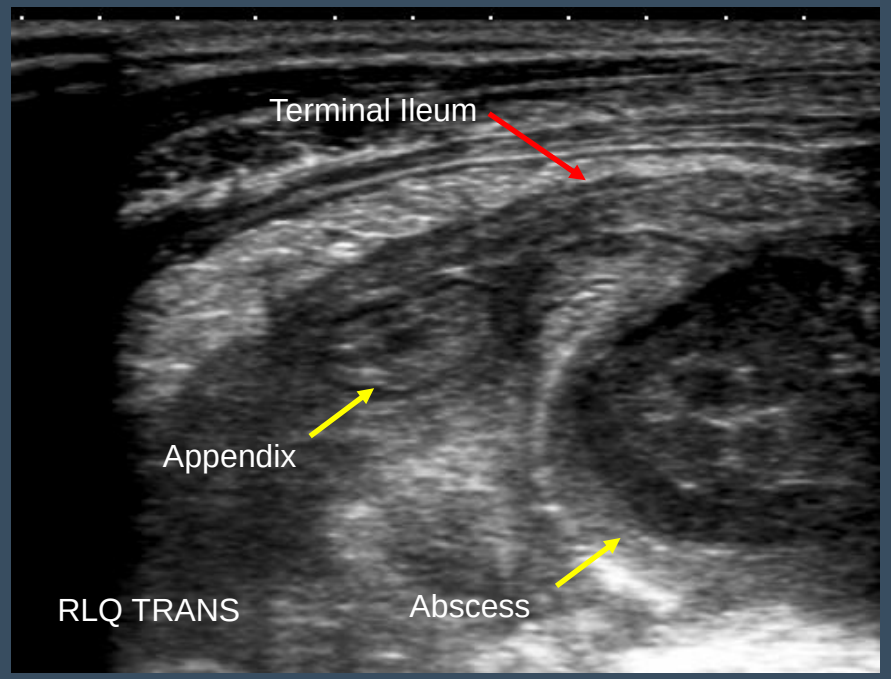
- Follow extent of inflammatory change to differentiate acute appendicitis from secondary involvement in a more generalized inflammatory process.

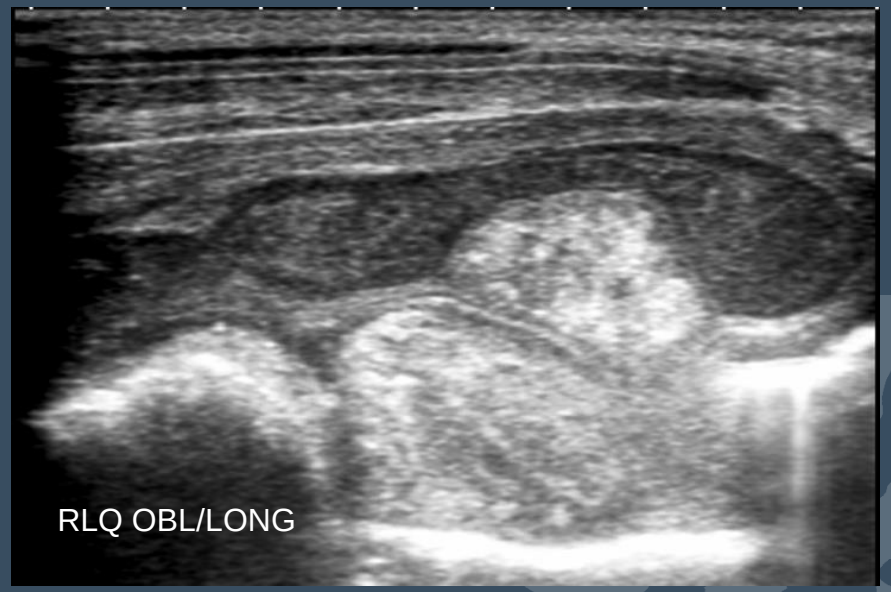
# Appendicitis vs Intussusception

History: 2-year-old with abdominal pain transferred to tertiary care pediatric hospital for ileocolic intussusception.

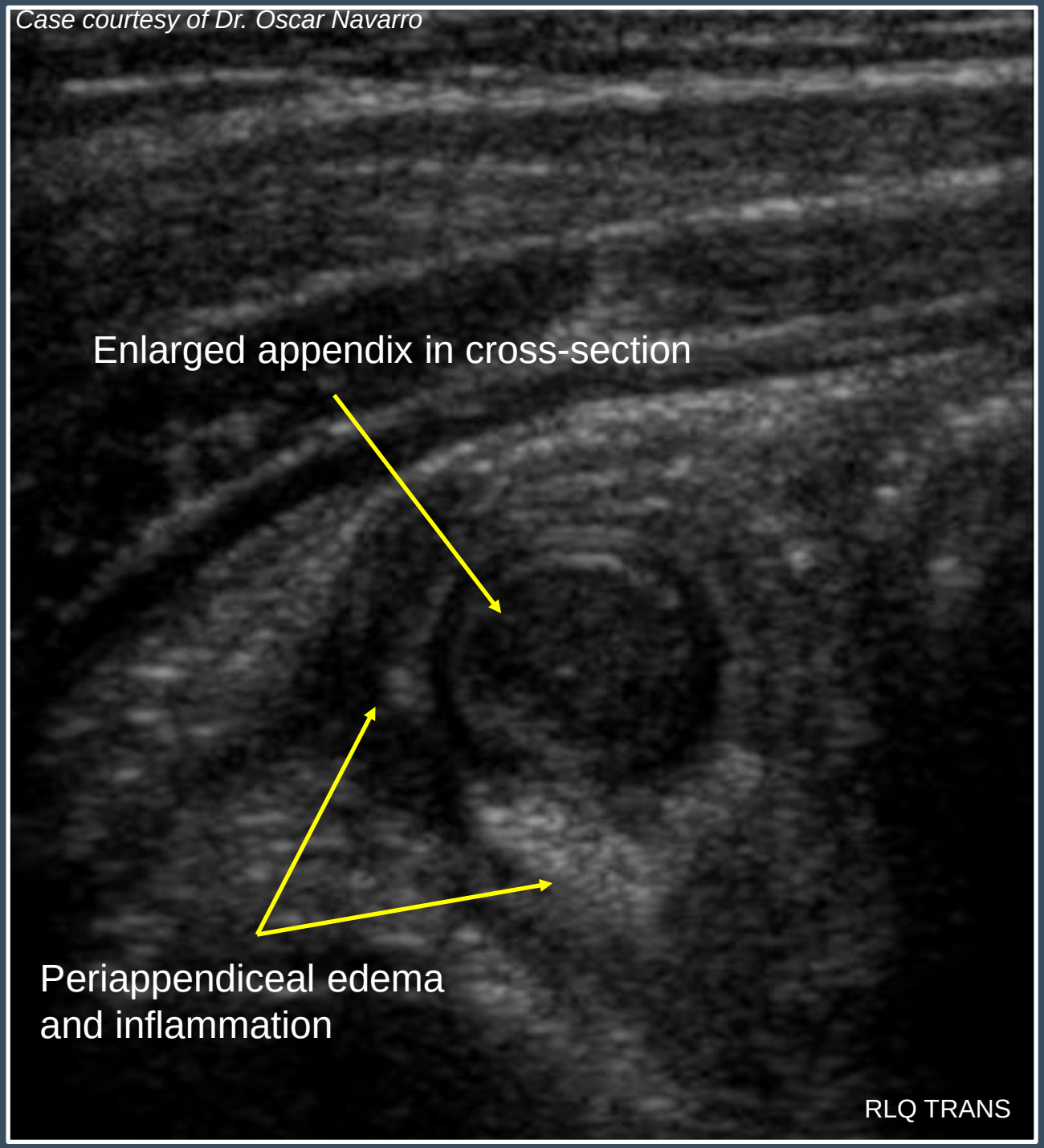



Outside Image: Interpreted as ileocolic intussusception




In-House Images: Appendicitis with abscess




# Appendicitis vs Intussusception

History: Pediatric patient with abdominal pain.

Findings:
Target-like structure at the right lower quadrant with crescentic hyperechoic component approximately 2 cm in diameter.

Management:
No ileocolic intussusception at air enema.

Diagnosis:
Surgical exploration revealed acute appendicitis.

**Teaching Point**

- Limited still images can be misleading
- Image full extent of pathology in multiple planes

# Small Bowel vs Ileocolic Intussusception

History: 9-year-old with abdominal distention

Findings:

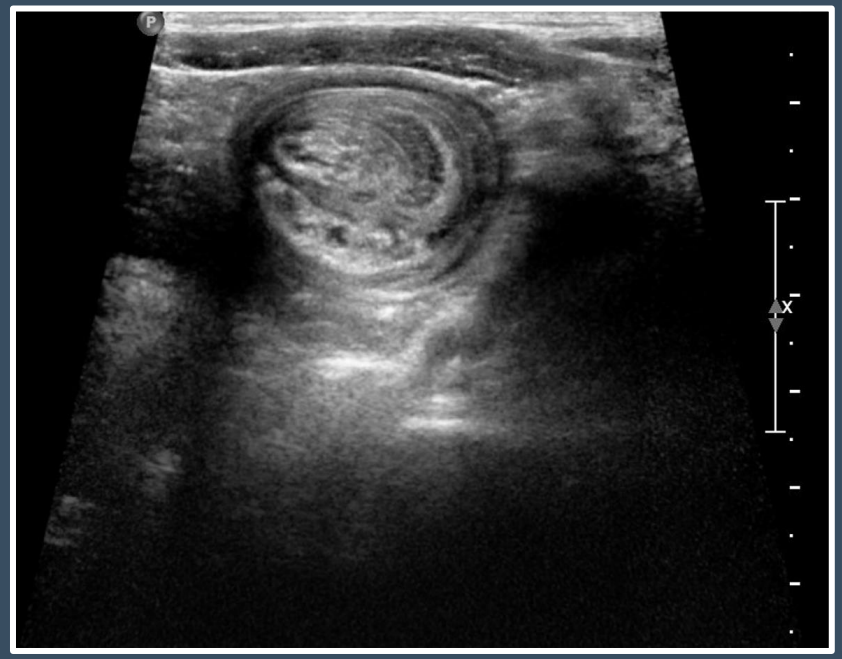
- Intussusception, 10 cm long
- Extends from RLQ → LLQ
- Diameter up to 2.5 cm
- Fat core > Outer wall thickness

Diagnosis:

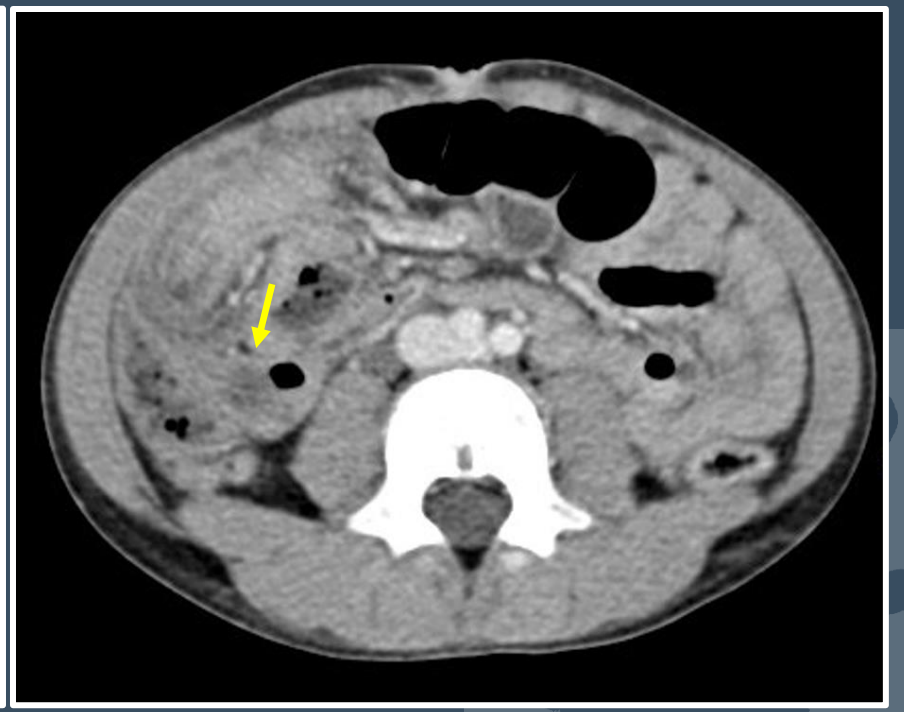
Long-segment small-bowel intussusception with Meckel diverticulm lead-point

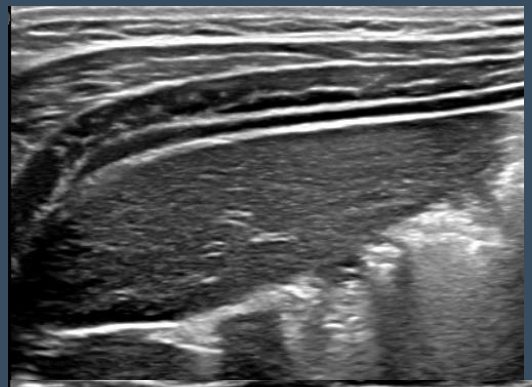
**Teaching Point**

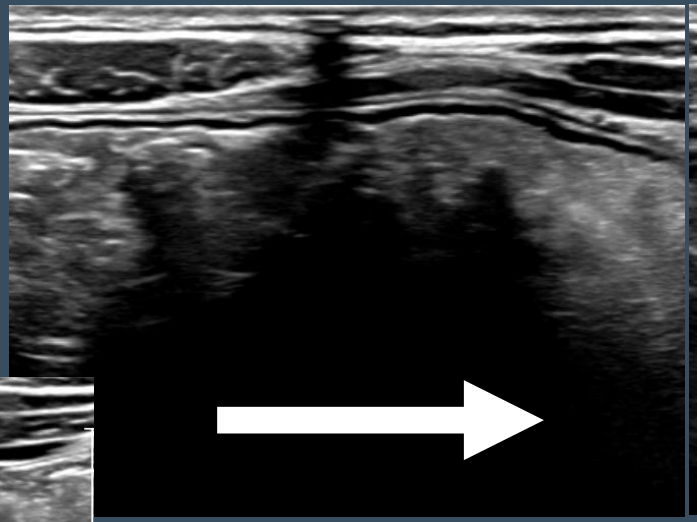
- Look for a normal terminal ileum to help differentiate small-bowel from ileocolic intussusception

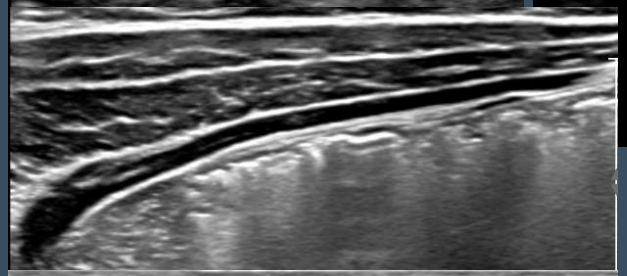


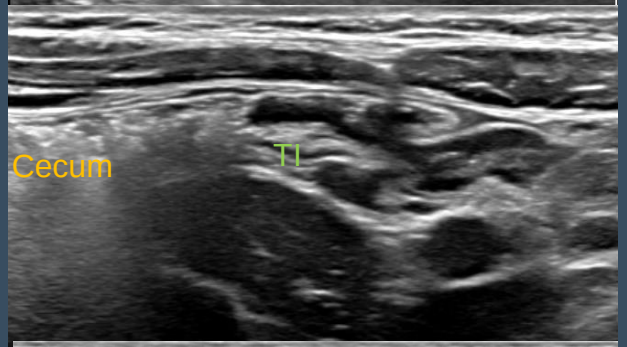








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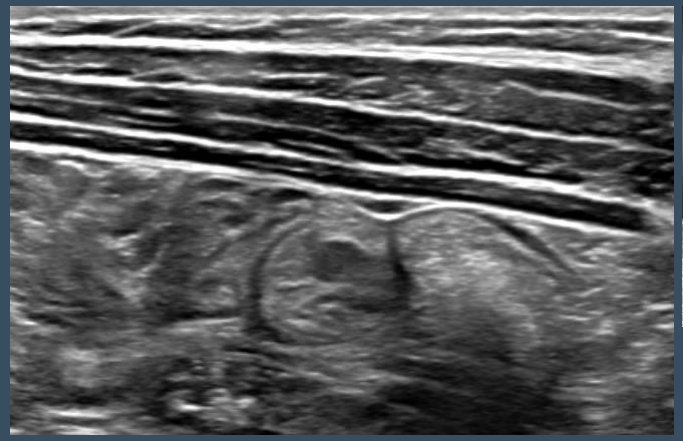
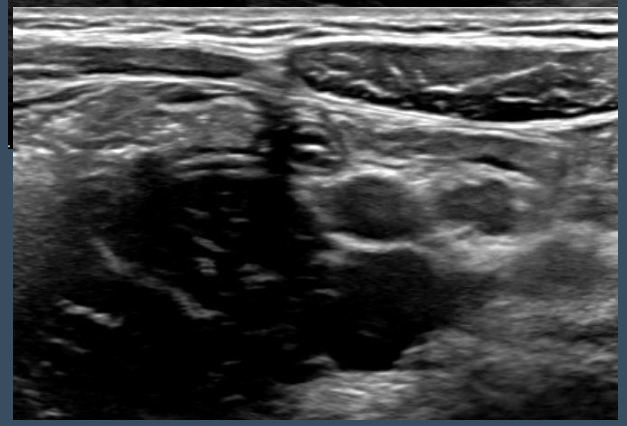
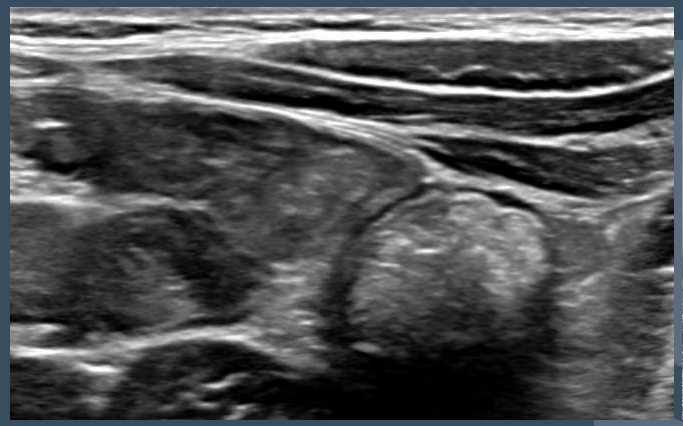
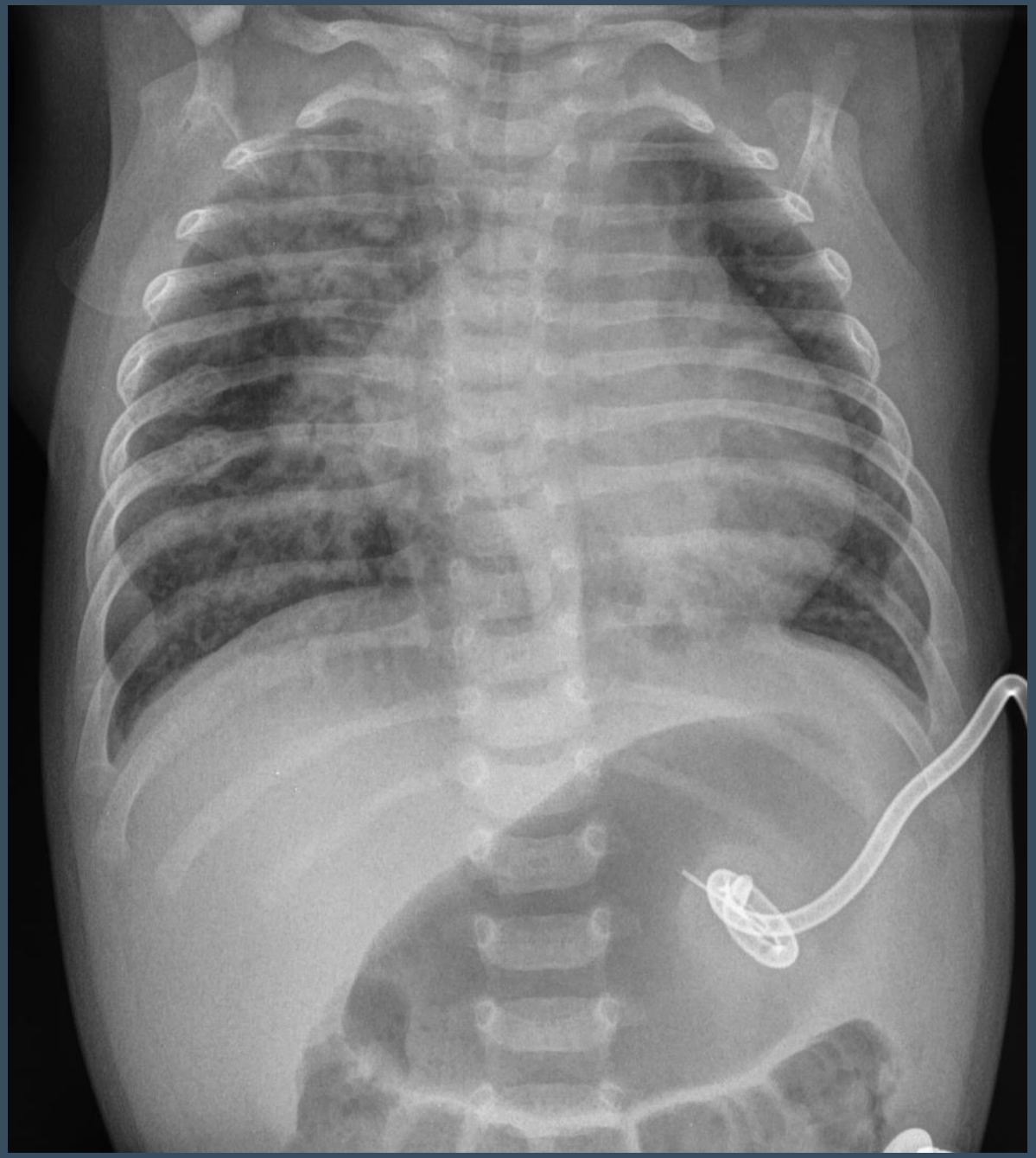
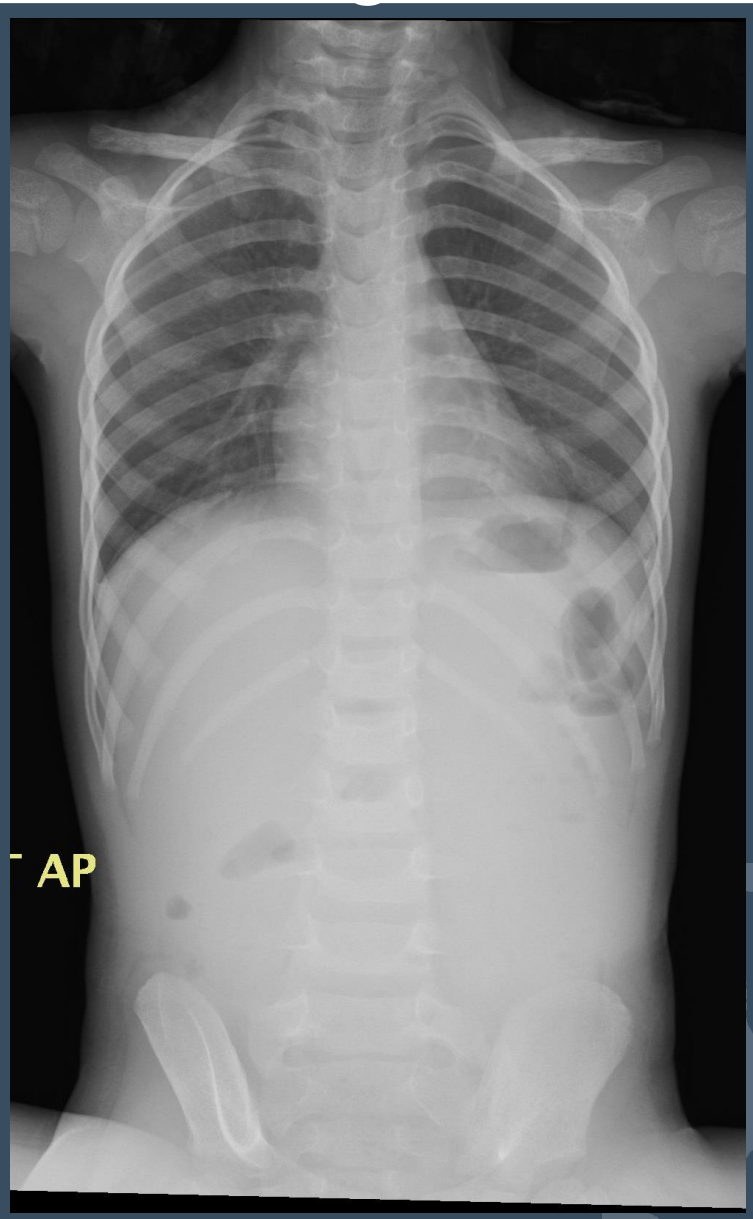




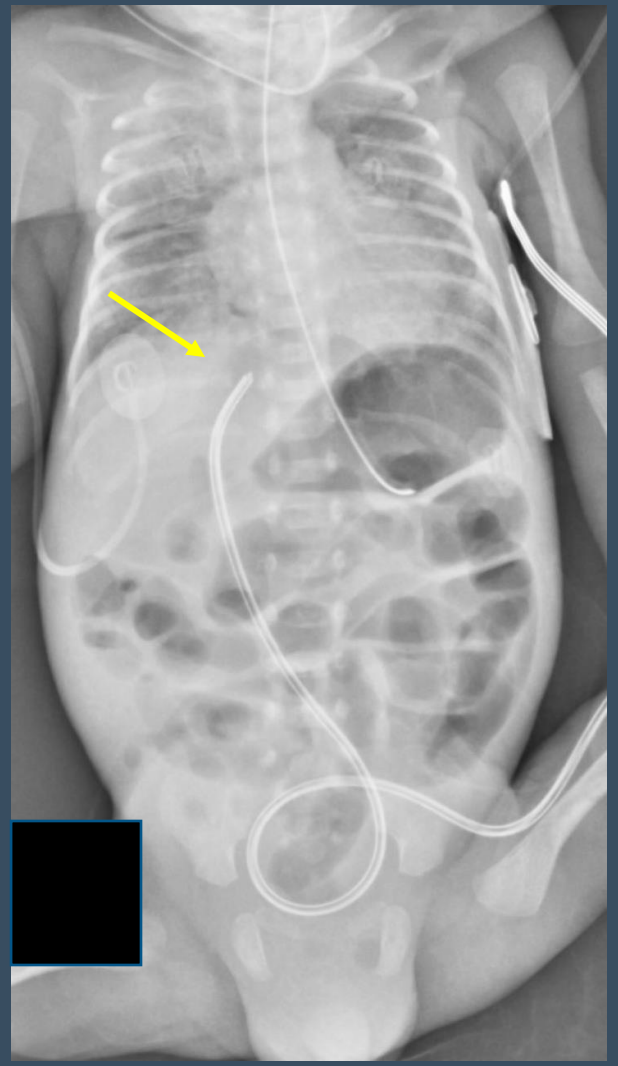


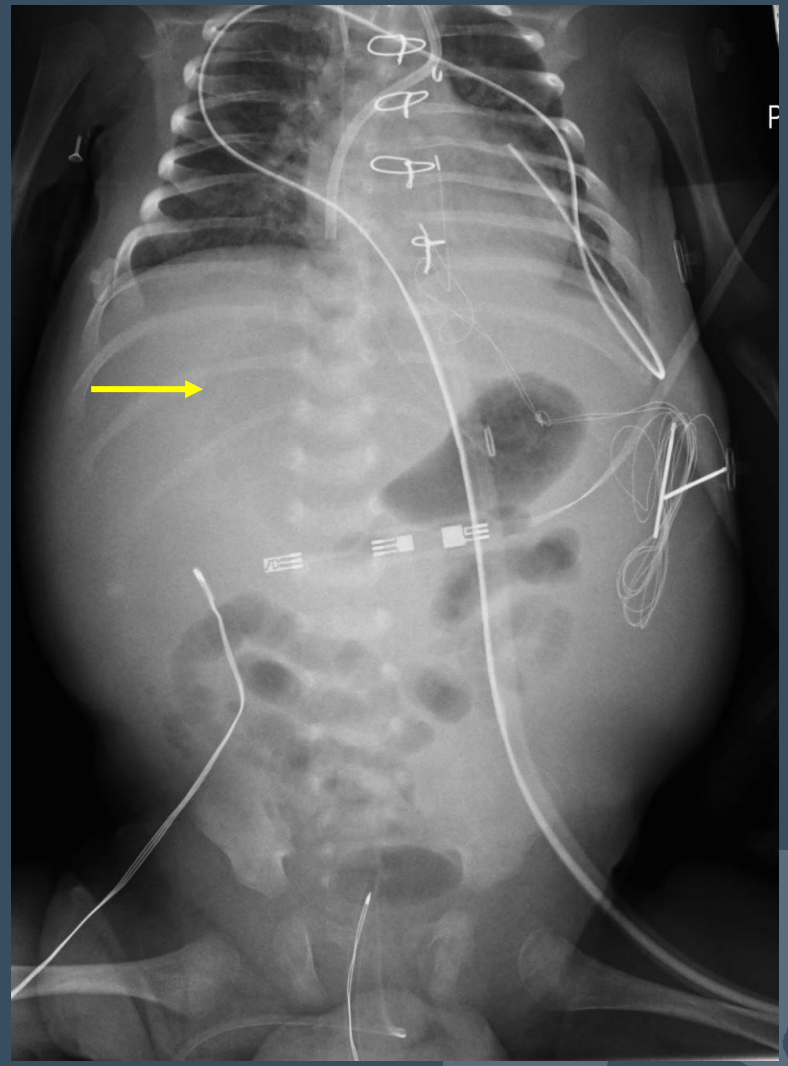
# Misleading Histories

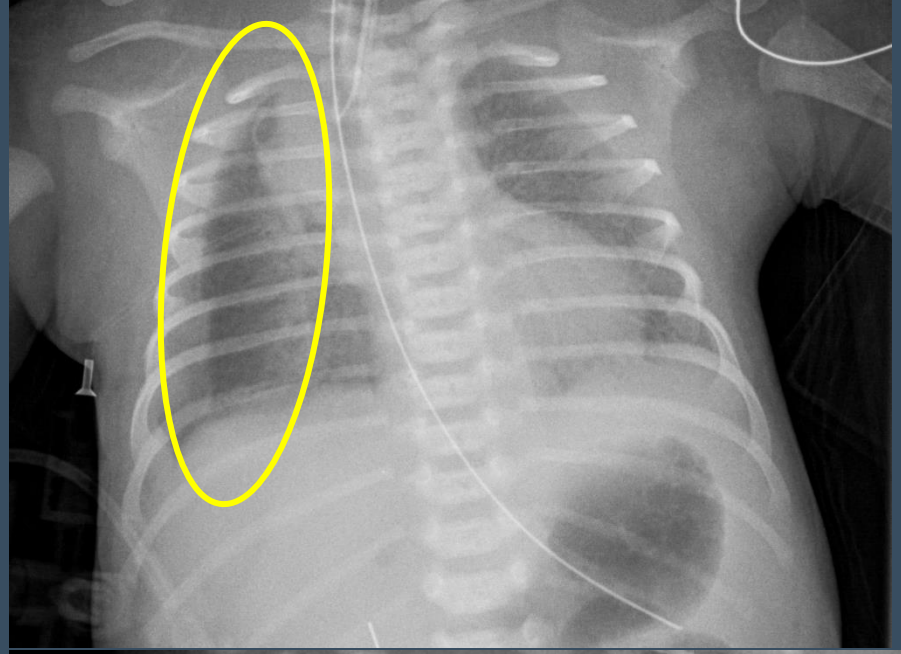


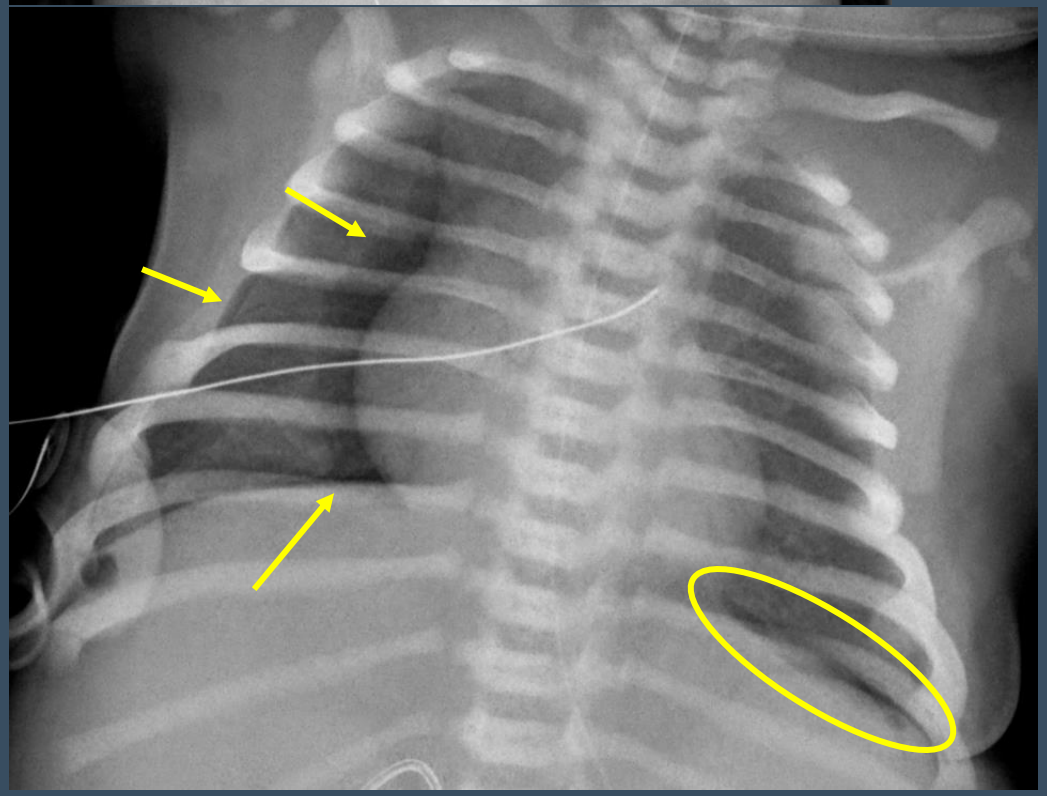


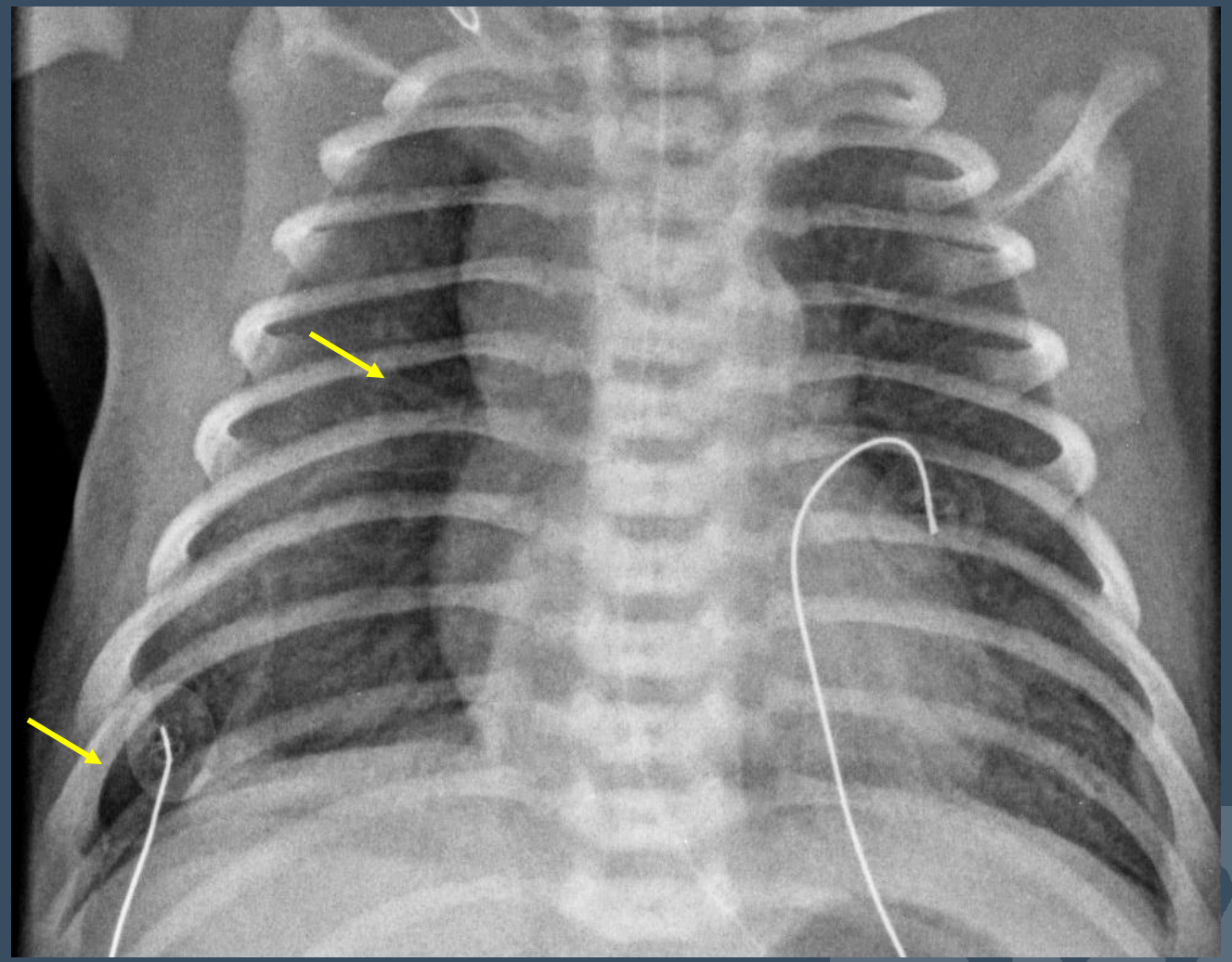
# Pneumoperitoneum

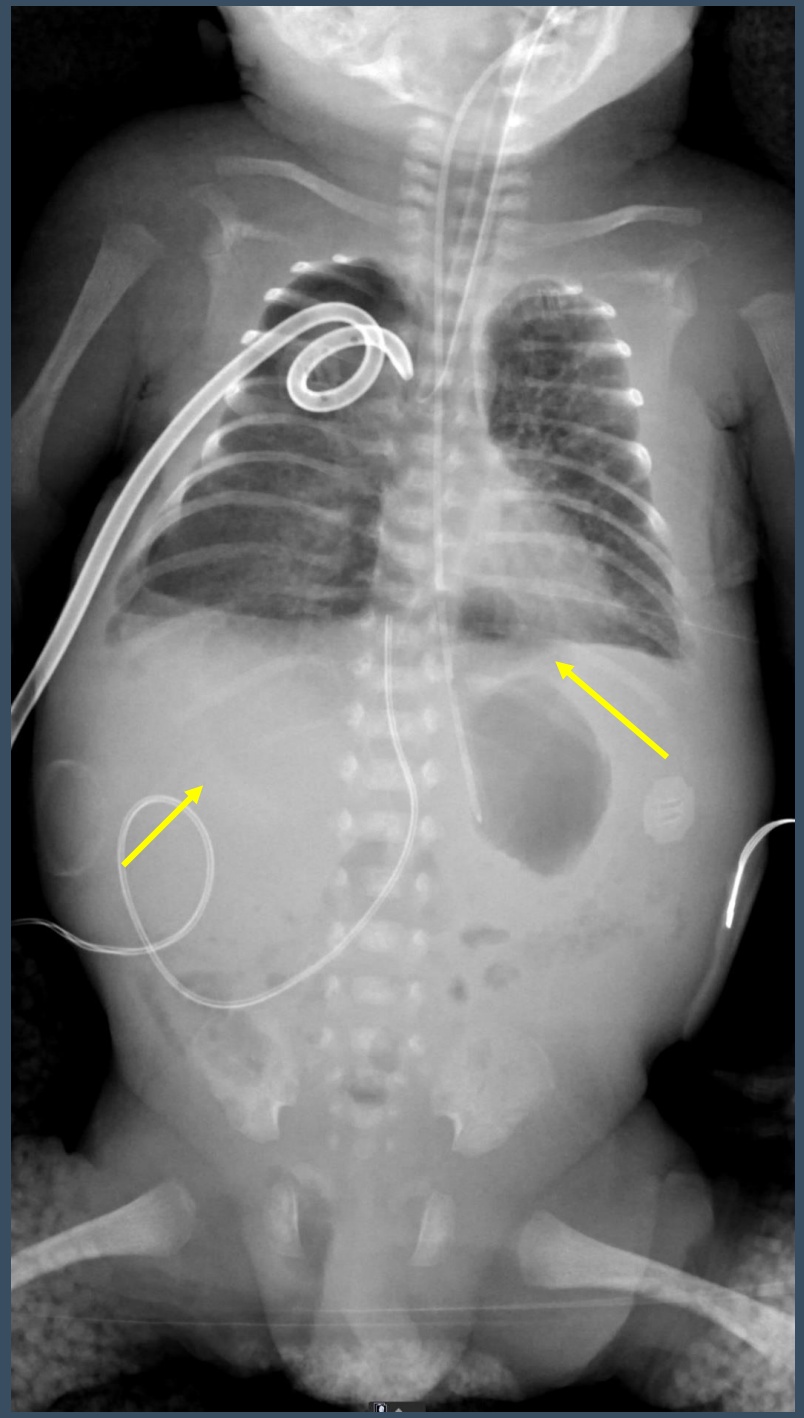




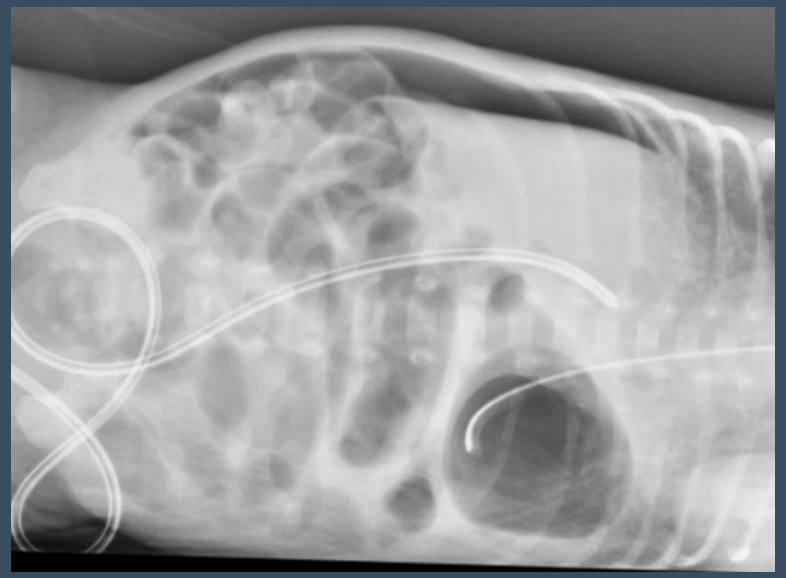


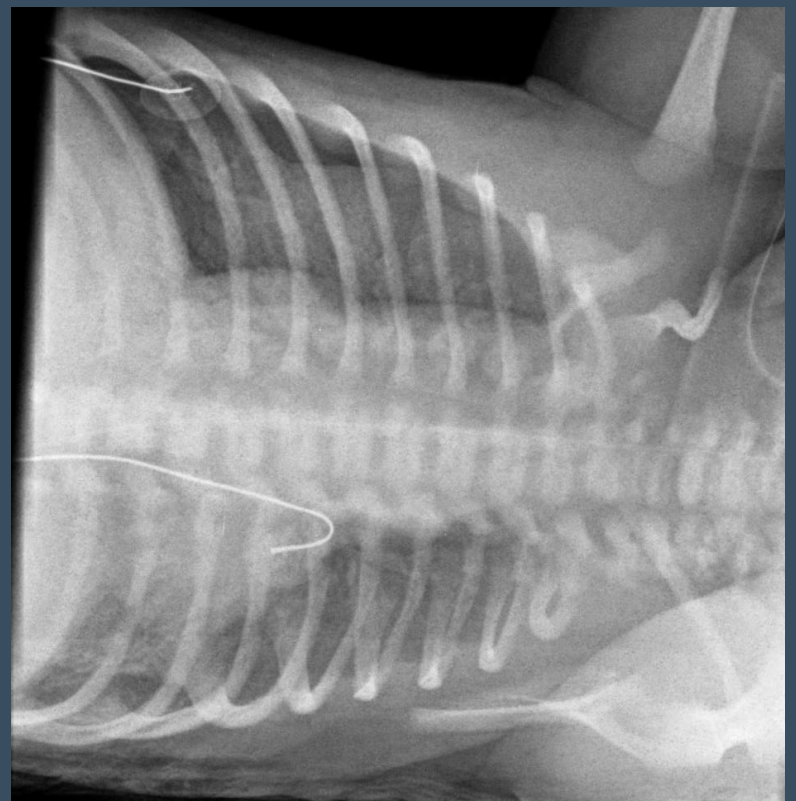


# Pneumothorax




# Cross-Table Lateral View



# Lateral Decubitus View

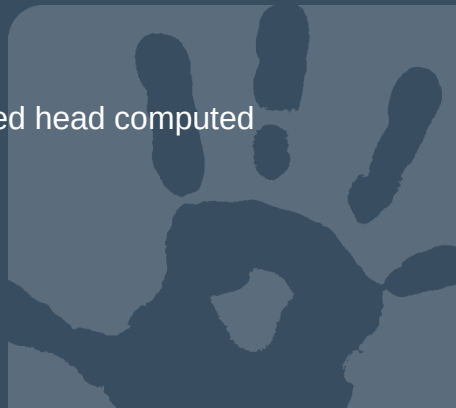
**Teaching Points**

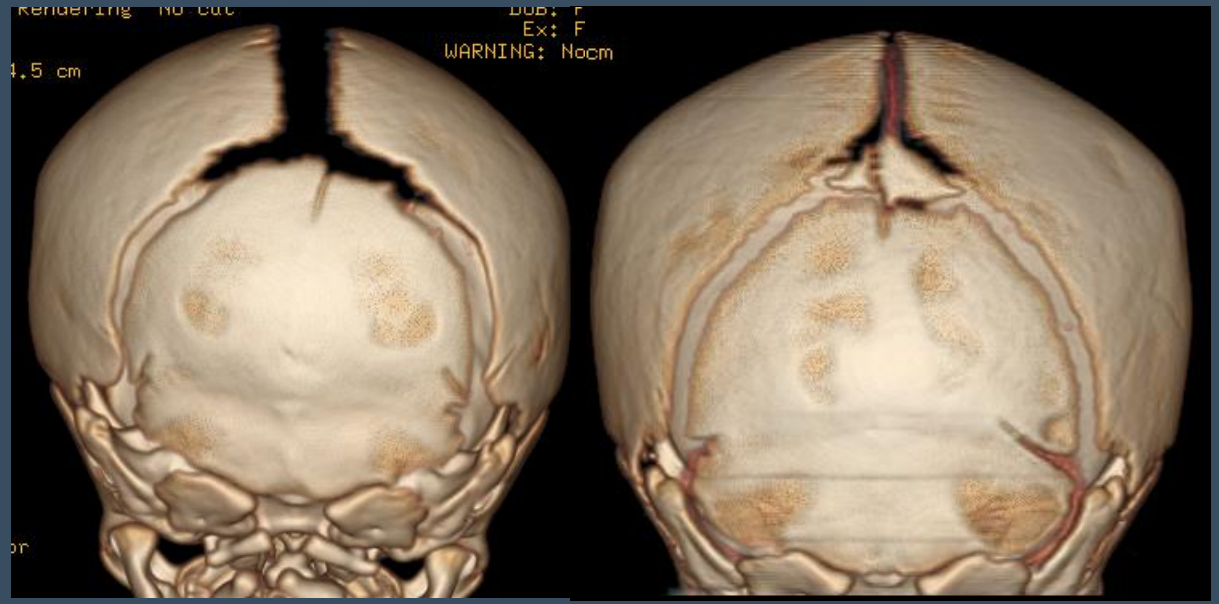
- Pneumoperitoneum and pneumothorax can be subtle in supine neonates
- Cross-table lateral and decubitus views can be helpful for diagnosis of pneumoperitoneum and pneumothorax
- Lateral decubitus views require patients to be on side for several minutes prior to acquiring image
- Cross-table lateral view may require less handling of the patient

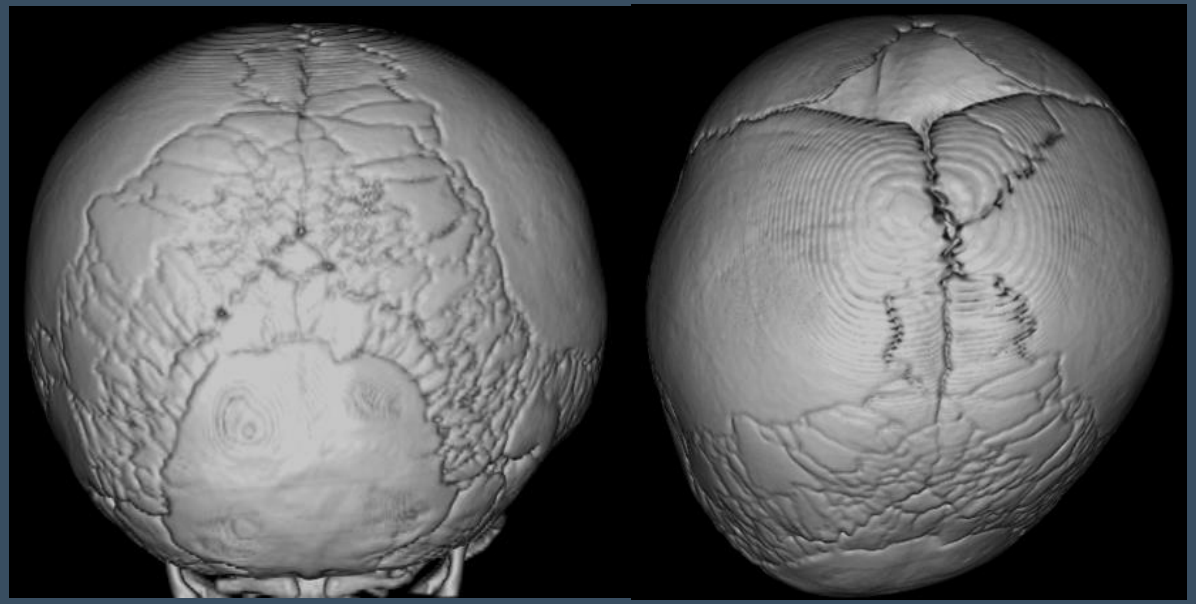
# Fractures vs Accessory Sutures & Wormian Bones & Artifact

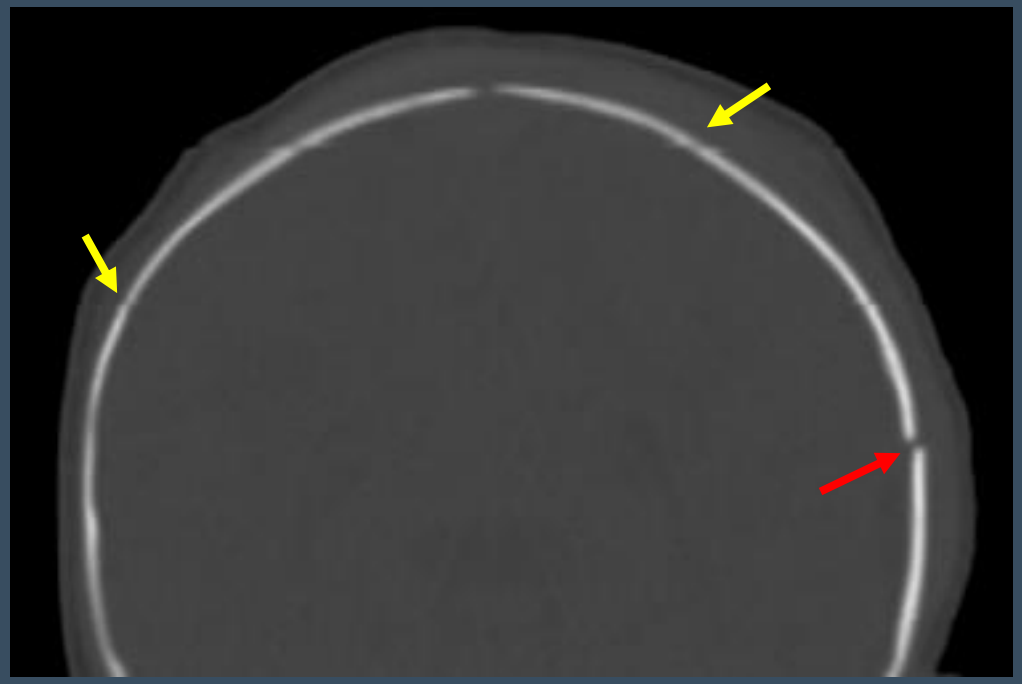
- Fractures: smooth, linear, may cross sutures and cause diastasis, look for associated intracranial injury or soft-tissue swelling
- Sutures: may have sclerotic margin, jagged/zig-zag appearance, may be symmetric, Wormian bones maybe intrasutural
- 3D images ↑ sensitivity and specificity for detection of fractures, including diastatic fractures of the sutures

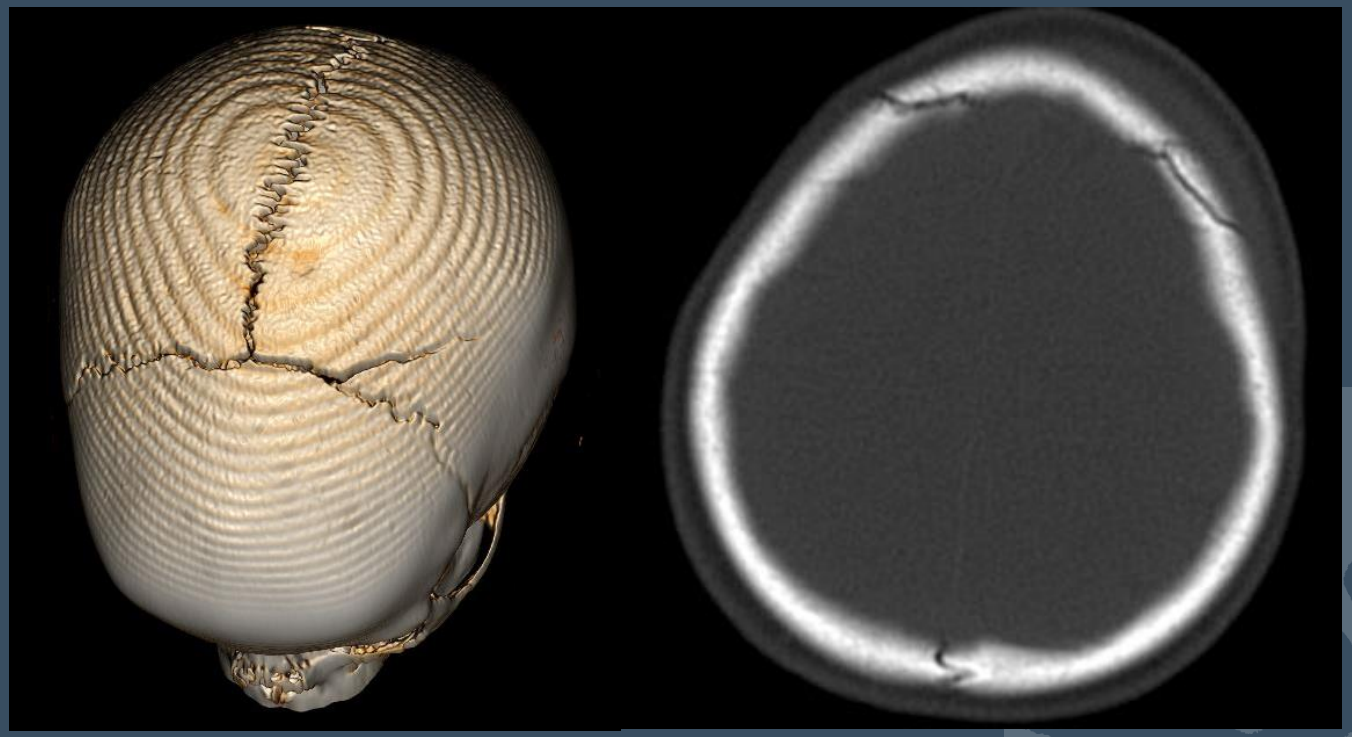
Purushothaman R, Desai S, Jayappa S, Choudhary AK, Ramakrishnaiah RH. Utility of three-dimensional and reformatted head computed tomography images in the evaluation of pediatric abusive head trauma. Pediatric radiology. 2021 May;51:927-38.




Ex: F
WARNING: Nocm
4.5 cm







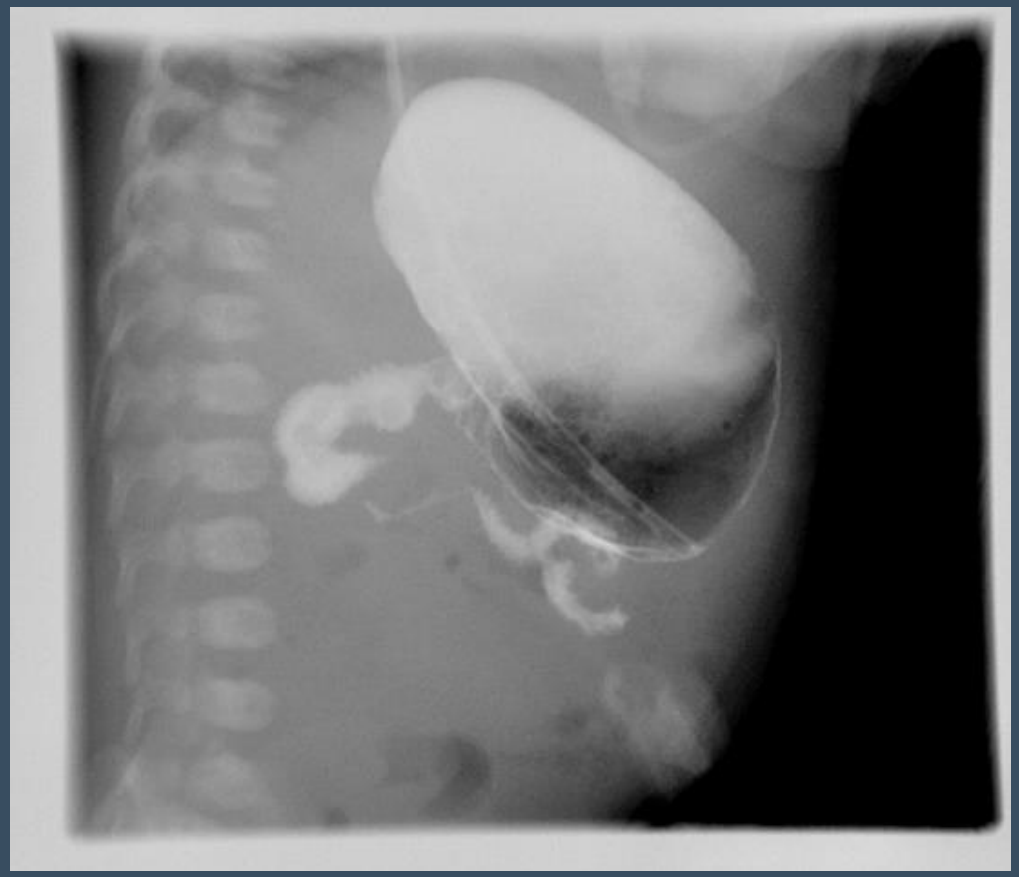
# Comparison Views



12 year-old pitcher

Medial Epicondyle Traction Apophysitis

Contralateral imaging can be helpful to confirm diagnosis.



# “Non-Obstructive Bowel Gas Pattern”

**Teaching Points**

- Malrotation with midgut volvulus cannot be excluded on radiographs
- Communication is critical

Cleveland Clinic Children's