

# Pediatric Chest Trauma

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**Cleveland Clinic Children's**



I have no financial relationships related to this presentation



## Acknowledgements:

- Dr. Summer Kaplan
- Dr. Brooke Lampl
- Dr. Samantha Gerrie



# Objectives

- Understand how differences in pediatric anatomy result in different injury patterns
- Be familiar with indications for imaging blunt chest trauma
- Understand the role of radiographs versus CT
- Identify imaging findings of blunt chest trauma in pediatric patients



# Epidemiology

- Blunt trauma >80% of chest trauma cases
  - MVA, peds vs motor vehicle, falls
- Indicator of severe trauma
  - Mortality 20X greater compared to children without chest trauma
  - Polytrauma in 50-81%
  - Isolated chest trauma mortality only 5%





Children are not just little adults

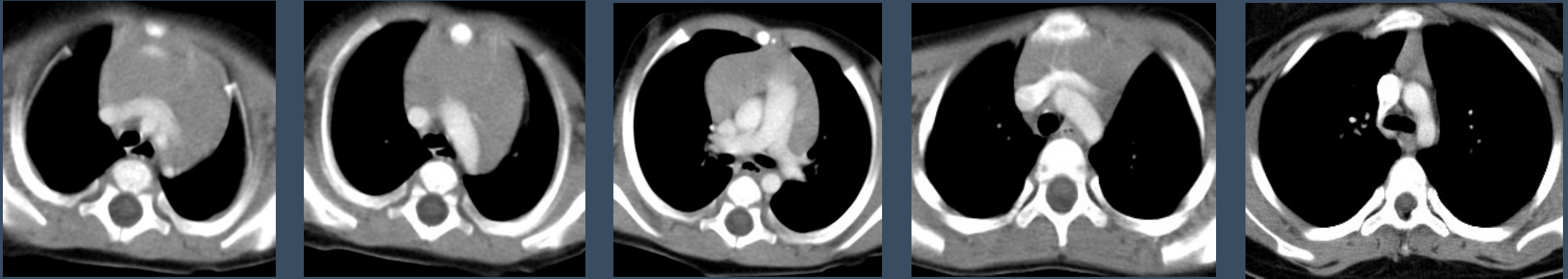


# Pediatric vs Adult Chest

- Chest wall more compliant
  - Rib fractures less common
  - Contusions more common (energy dissipated in lung parenchyma)
- Mediastinum more mobile
  - Mediastinal shift → respiratory & vascular compromise more common
- Aortic trauma much less common
  - Greater elasticity of arterial structures in chest
  - Less atherosclerosis



# Normal Thymus



- Large, nearly fully developed at birth
- Soft, no mass effect, small degree of transparency
- Gradually involutes after the age of 2-years, usually difficult to visualize after age of 8-years on radiograph



# Risk of Radiation Exposure

- ↑ Risk for radiation-induced carcinogenesis
  - More active organ and tissue growth
  - Longer life expectancy during which potential oncogenic effects of radiation can manifest
  - Estimated cancer risk from chest CT
    - Female: 25/10,000
    - Male: 7.5/10,000
- Methods of decreasing radiation exposure:
  - Perform studies when indicated
  - Diagnostic techniques with radiation doses ALARA

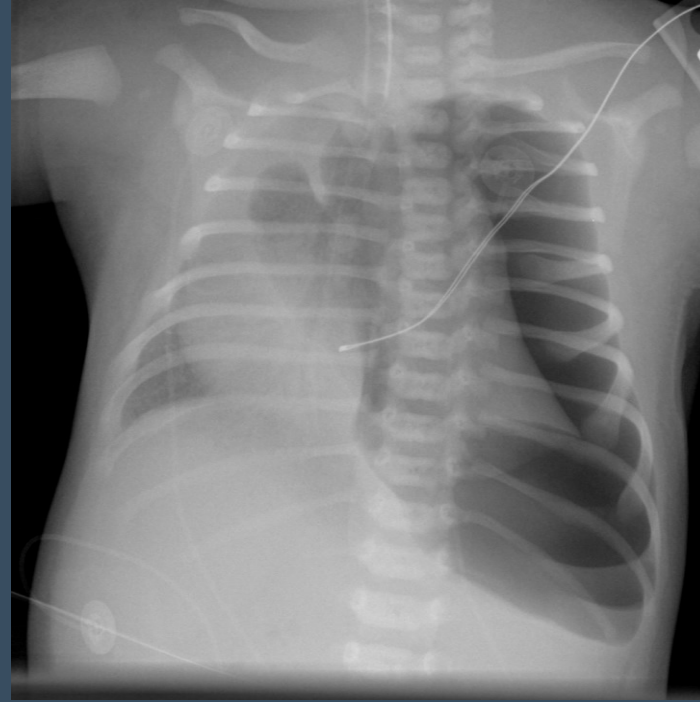
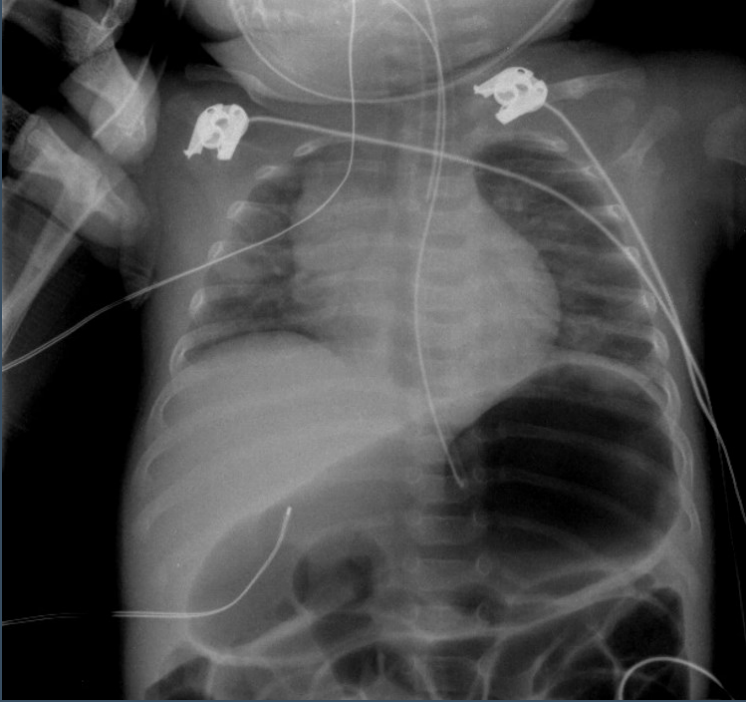


# Imaging Indications and Algorithms

- No widely accepted imaging algorithm in North America for pediatric blunt chest trauma
- No large prospective studies to guide care
- Age cut-off for pediatric patients varies between institutions
- Adult-oriented institutions have higher utilization of chest CT



# Imaging Indications and Algorithms



## Chest radiographs

- 1<sup>st</sup> line
- ATLS work-up
- Negative predictive value 96% for intrathoracic vascular injury



# Imaging Indications and Algorithms

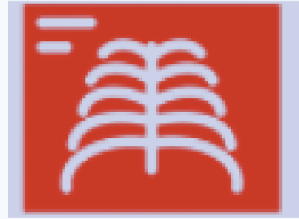
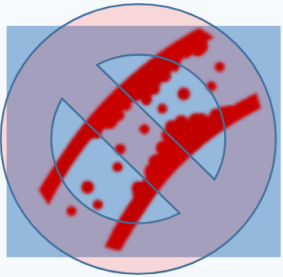
## CTA

- ↑ Sensitivity for detection of intrathoracic injury
- >95% sensitivity and specificity for detection of aortic injury
- Additional findings on CT rarely change patient management and outcome
- 91% Of findings requiring intervention could be made 1 cm above the dome of the liver
  
- Commonly used indications for CTA
  - Abnormal chest radiograph (widened mediastinum)
  - Seatbelt sign
  - High-energy trauma with rapid deceleration or thoracic compression
  - GCS <15
  - Abnormal vital signs

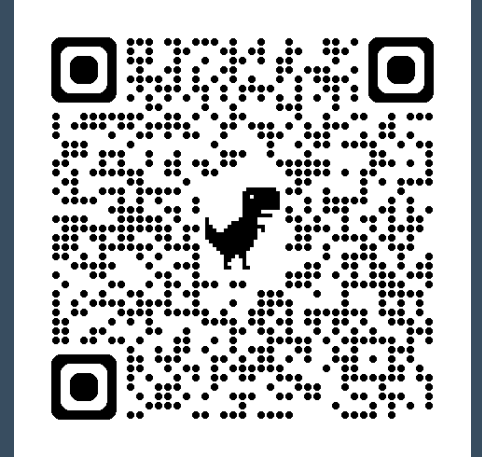


# Imaging Indications and Algorithms

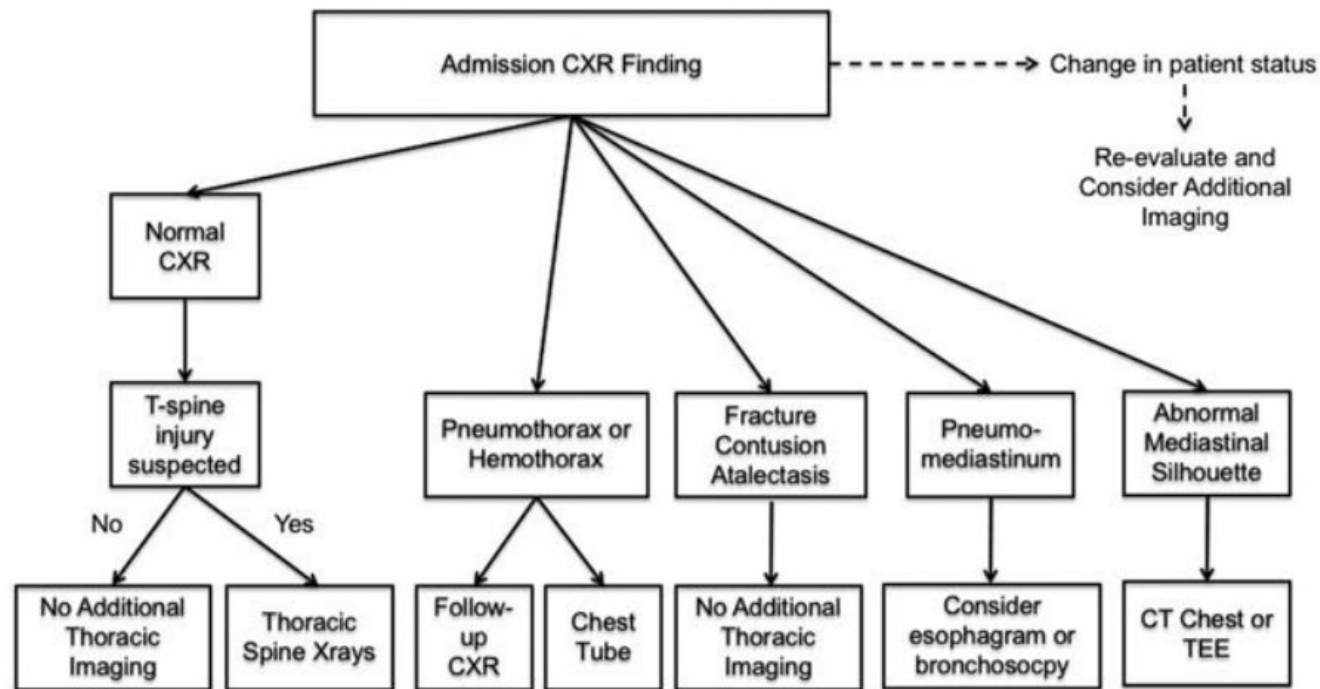
## Thoracic Imaging Assessment in the Setting of Blunt Trauma in Children



- Chest computed tomography (CCT) advocated in adult blunt trauma due to higher incidence of aortic injuries
- Majority of injuries can be identified and intervened on from chest radiography (CXR)
- CCT identifies more injuries but rarely changes clinical management
- CCT associated with increased lifetime cancer risk (references), equivalent to 150 CXR
- Traumatic vasculature injuries rare in children
- Screening with abnormal silhouette may decrease CCT use without missing significant vascular injuries

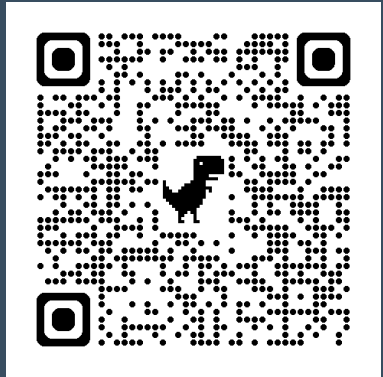


# Imaging Indications and Algorithms

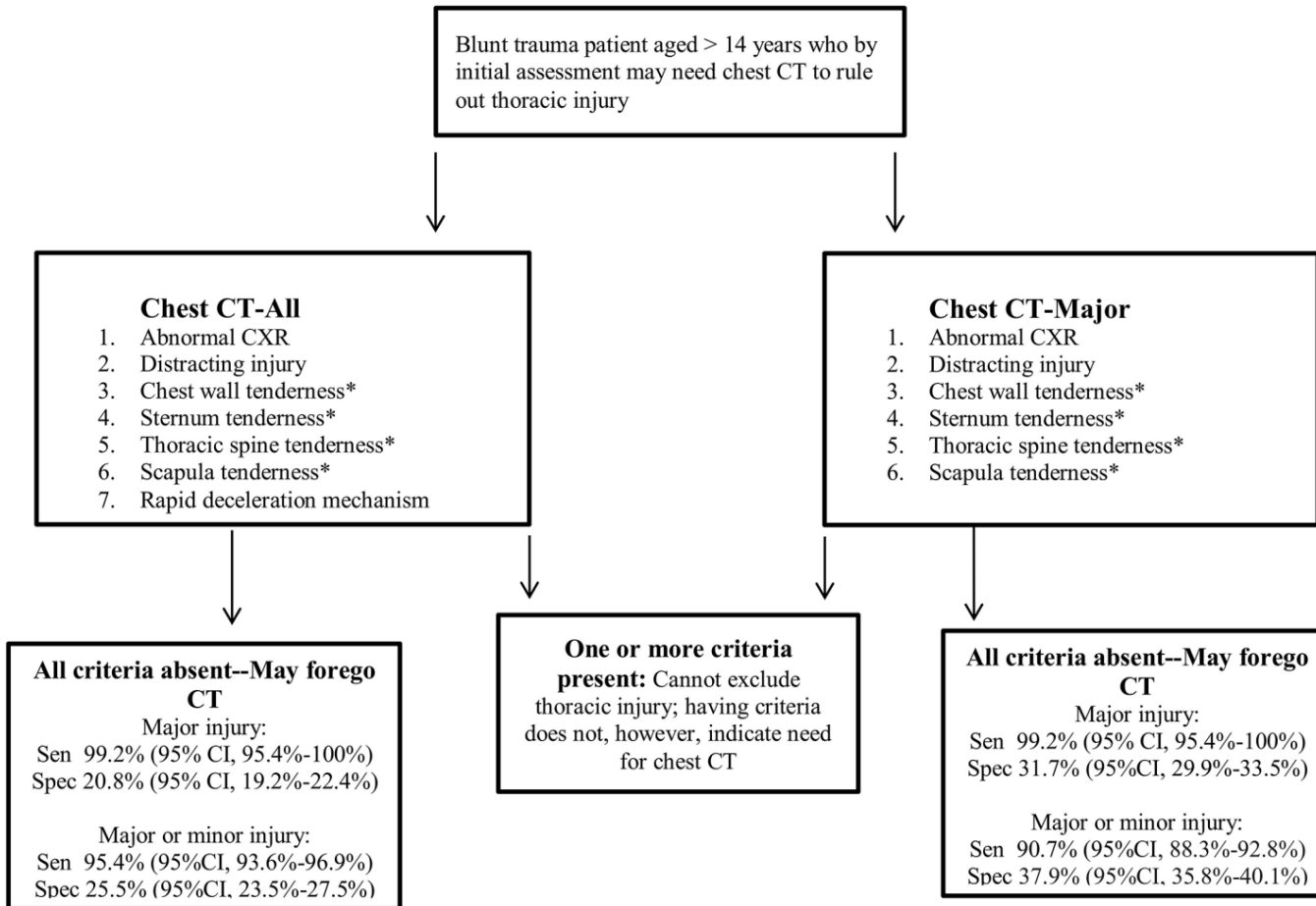


**Figure 3.** Imaging algorithm for pediatric blunt thoracic trauma patients.

Golden J, Isani M, Bowling J, Zagory J, Goodhue CJ, Burke RV, Upperman JS, Gayer CP. Limiting chest computed tomography in the evaluation of pediatric thoracic trauma. *Journal of Trauma and Acute Care Surgery*. 2016 Aug 1;81(2):271-7.



# Imaging Indications and Algorithms



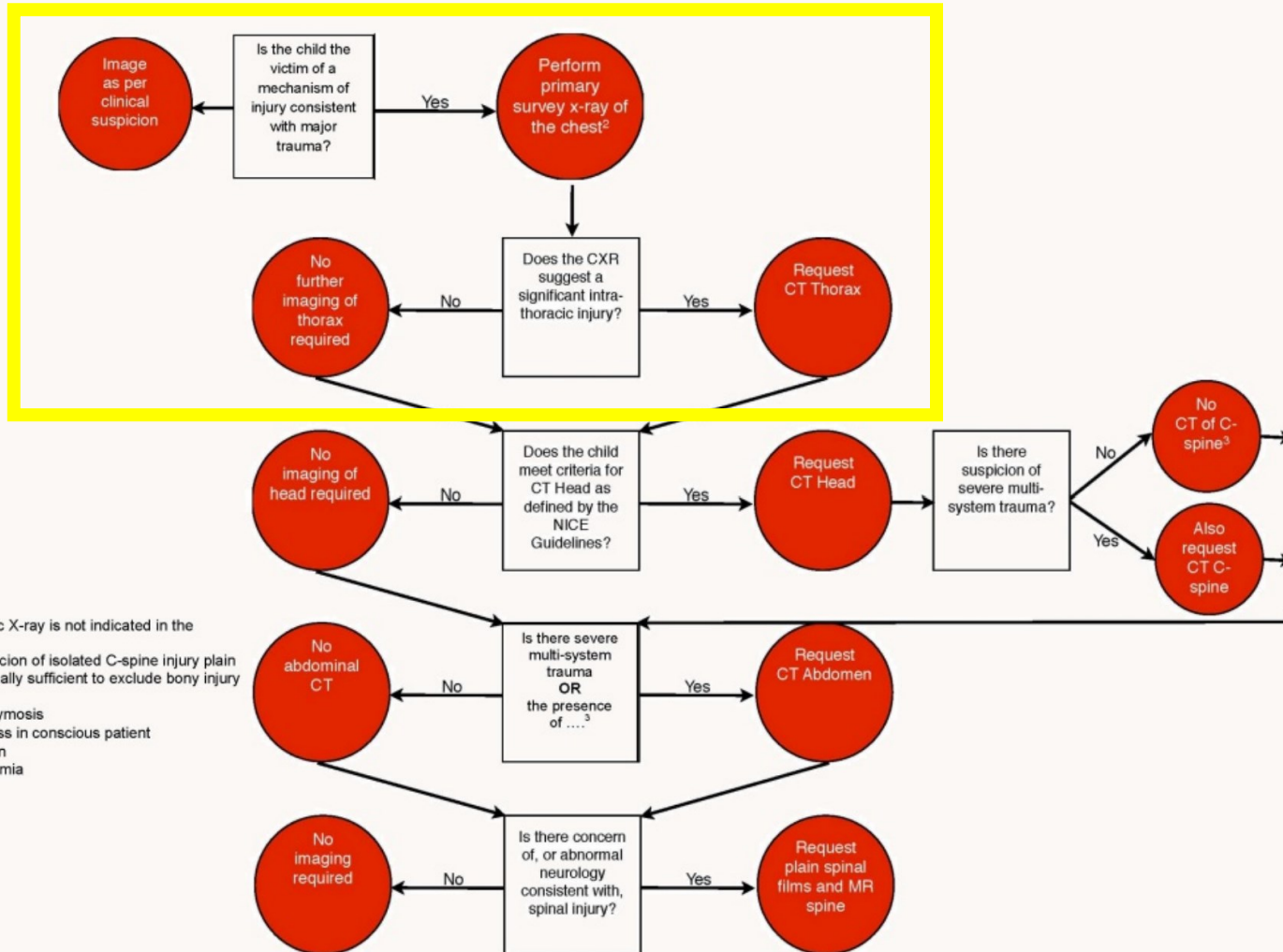
## NEXUS Chest

- Patients >14 years old
- Negative predictive value >99% for major thoracic injuries

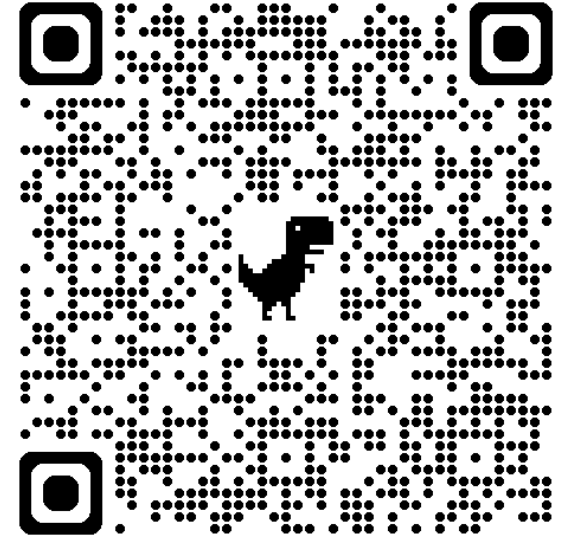
**Fig 2. NEXUS Chest CT decision instrument implementation.** Abnormal CXR is any thoracic injury (including clavicle fracture) or a widened mediastinum. Rapid deceleration mechanism is a fall from >20 feet (6.1 m) or a motor vehicle accident at >40 miles (64.4 km) per hour with sudden deceleration. Thoracic injury is defined as pneumothorax, hemothorax, aortic or great vessel injury, multiple rib fractures, ruptured diaphragm, sternal fracture, scapular fracture, thoracic spine fracture, esophageal injury, tracheal/bronchial injury, or pulmonary contusion/laceration. \*These four criteria may be evaluated together as any thoracic wall, sternal, spine, or scapular tenderness. Sen, sensitivity; Spec, specificity.

Rodriguez RM, Langdorf MI, Nishijima D, Baumann BM, Hendey GW, Medak AJ, Raja AS, Allen IE, Mower WR. Derivation and validation of two decision instruments for selective chest CT in blunt trauma: a multicenter prospective observational study (NEXUS Chest CT). *PLoS medicine*. 2015 Oct 6;12(10):e1001883.

# Imaging Indications and Algorithms

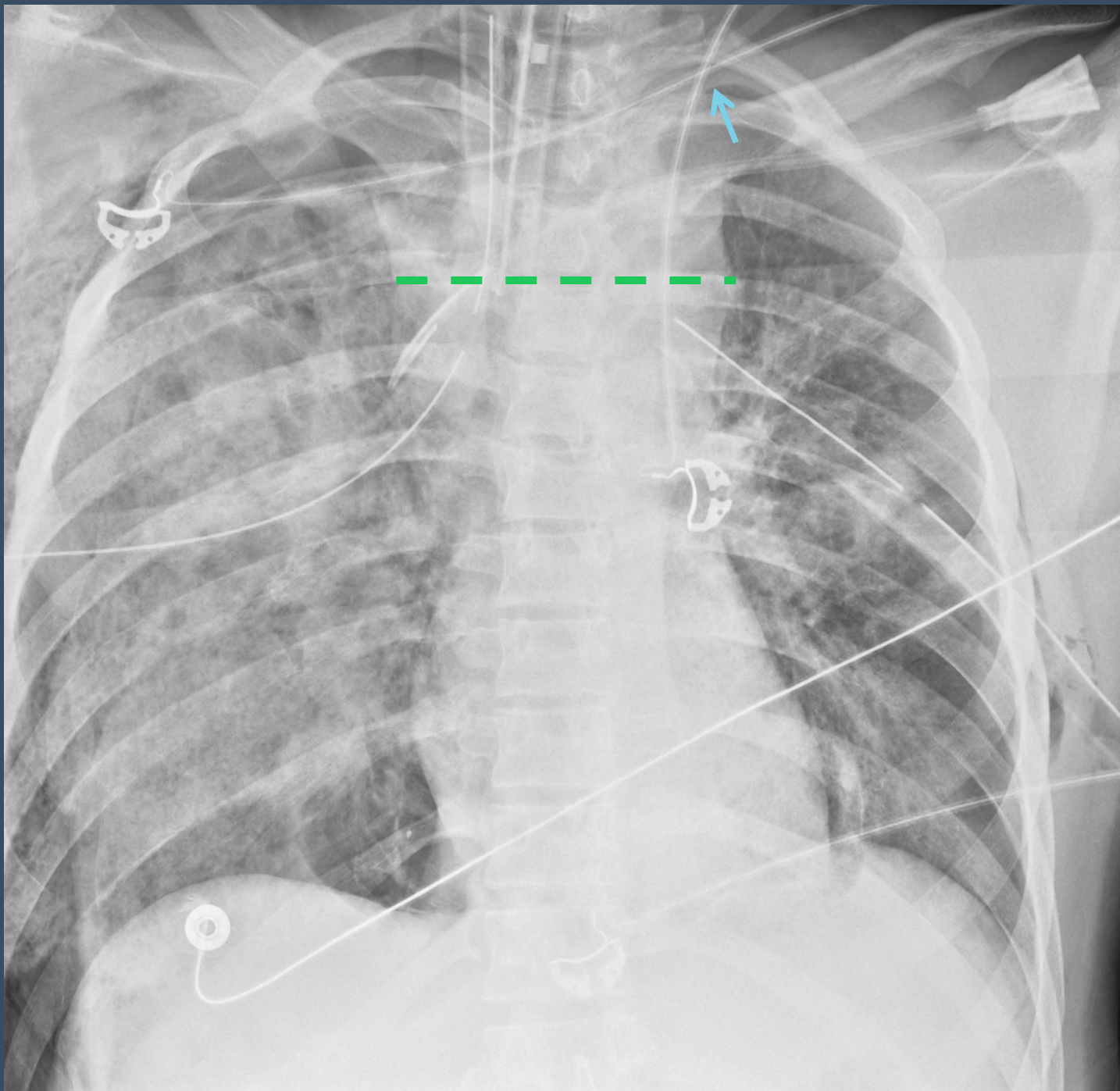


- Notes
1. A primary survey pelvic X-ray is not indicated in the paediatric population
  2. If there is clinical suspicion of isolated C-spine injury plain C-spine films are normally sufficient to exclude bony injury
  3. i) Lap belt injury  
 ii) Abdominal wall ecchymosis  
 iii) Abdominal tenderness in conscious patient  
 iv) Abdominal distension  
 v) Persistent hypovolaemia  
 vi) PR or NG blood



The Royal College of Radiologists. Paediatric trauma protocols. London: The Royal College of Radiologists. 2014.





## CASE 1

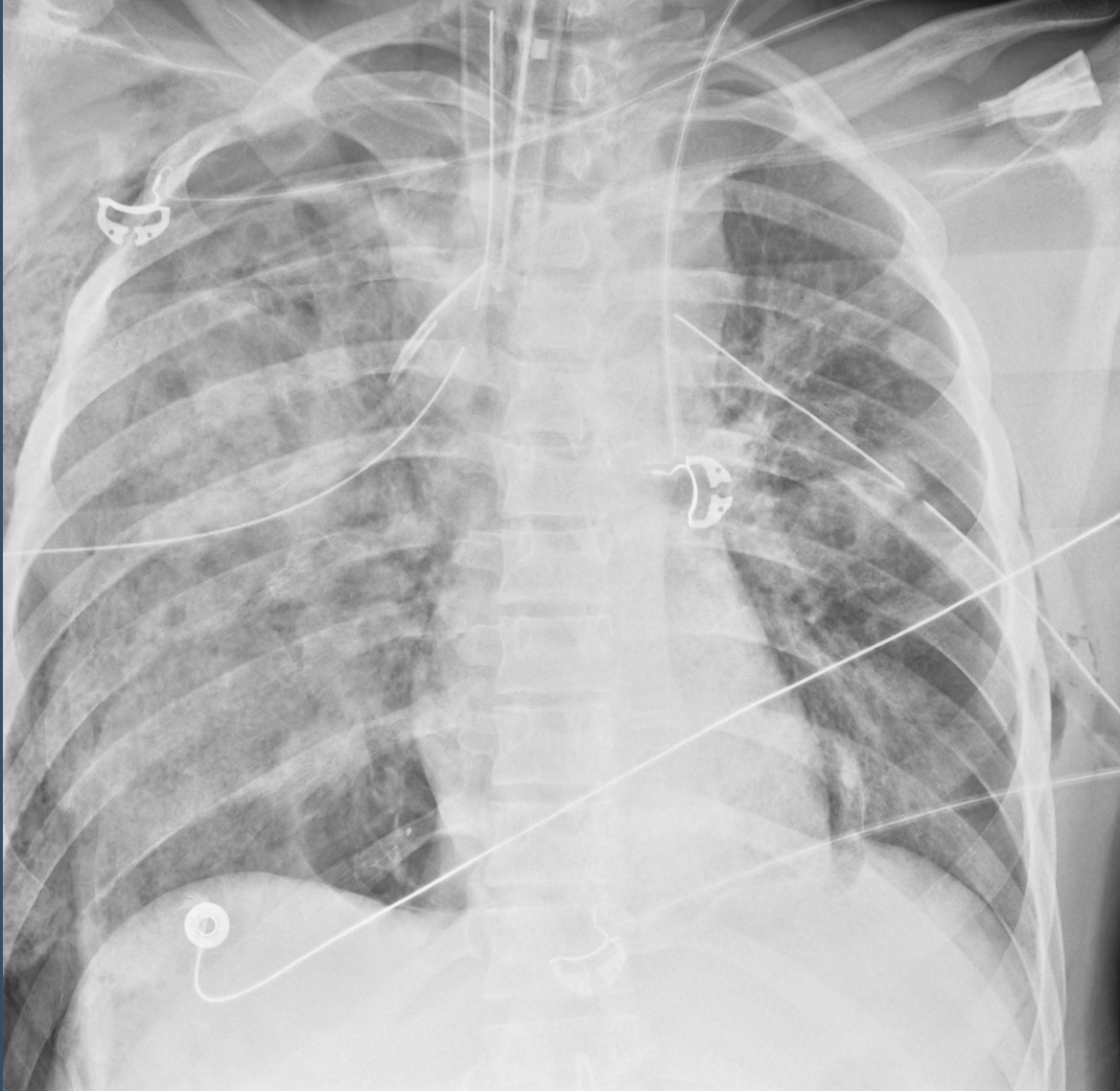
History: Motor vehicle accident

Findings:

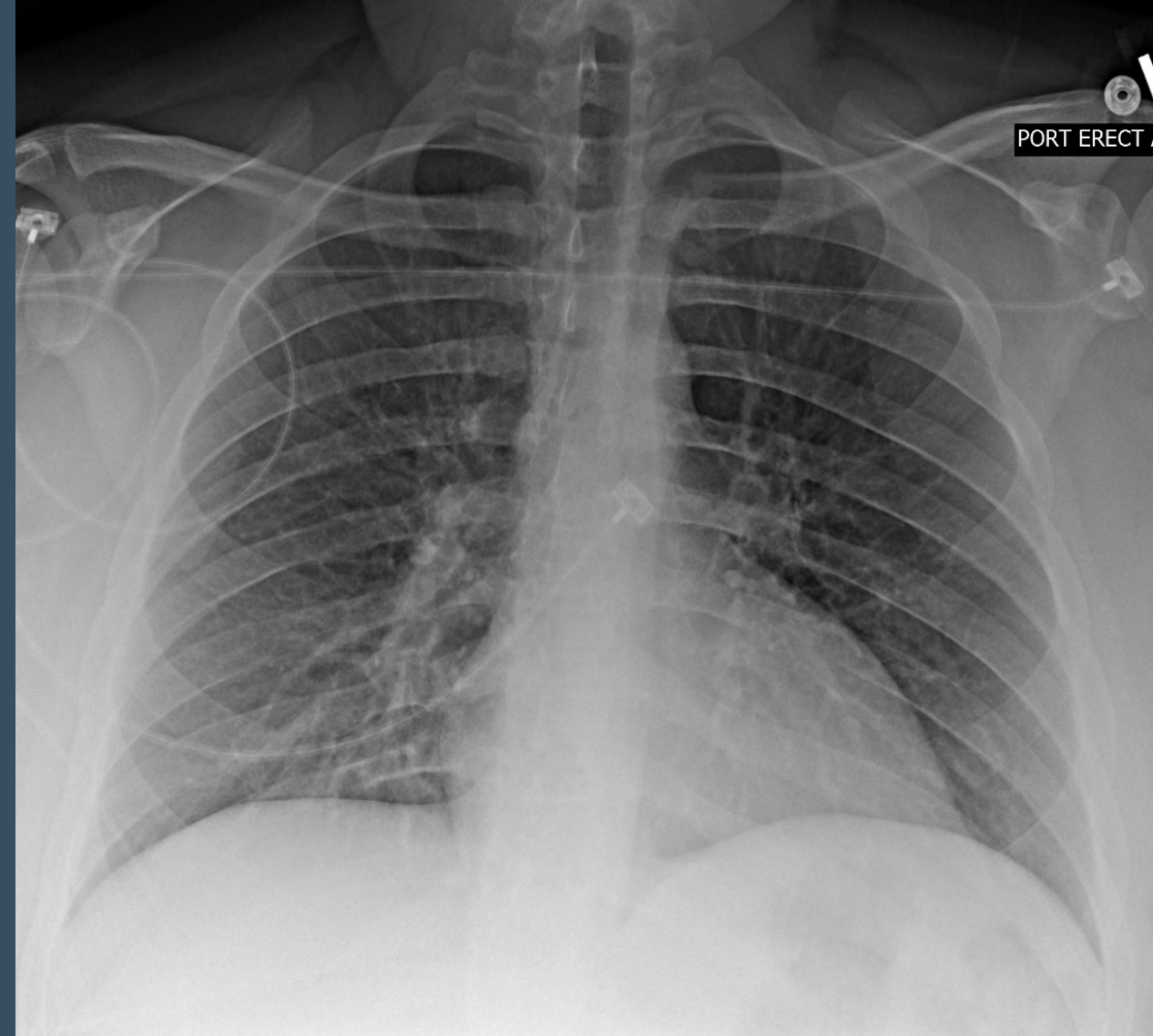
- Wide mediastinum (-----)
- Left apical cap (→)



# Case 1



# Comparison

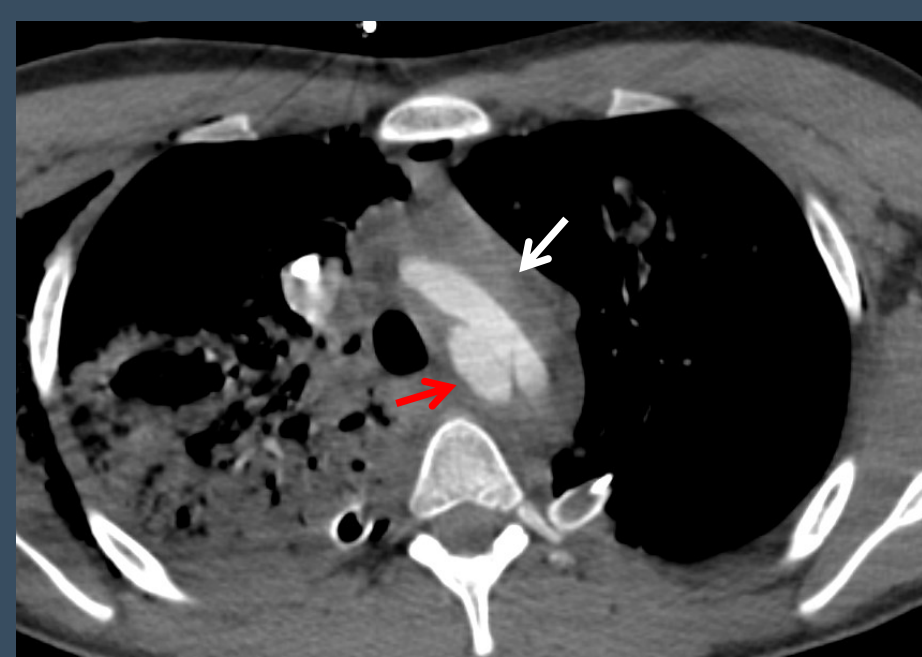


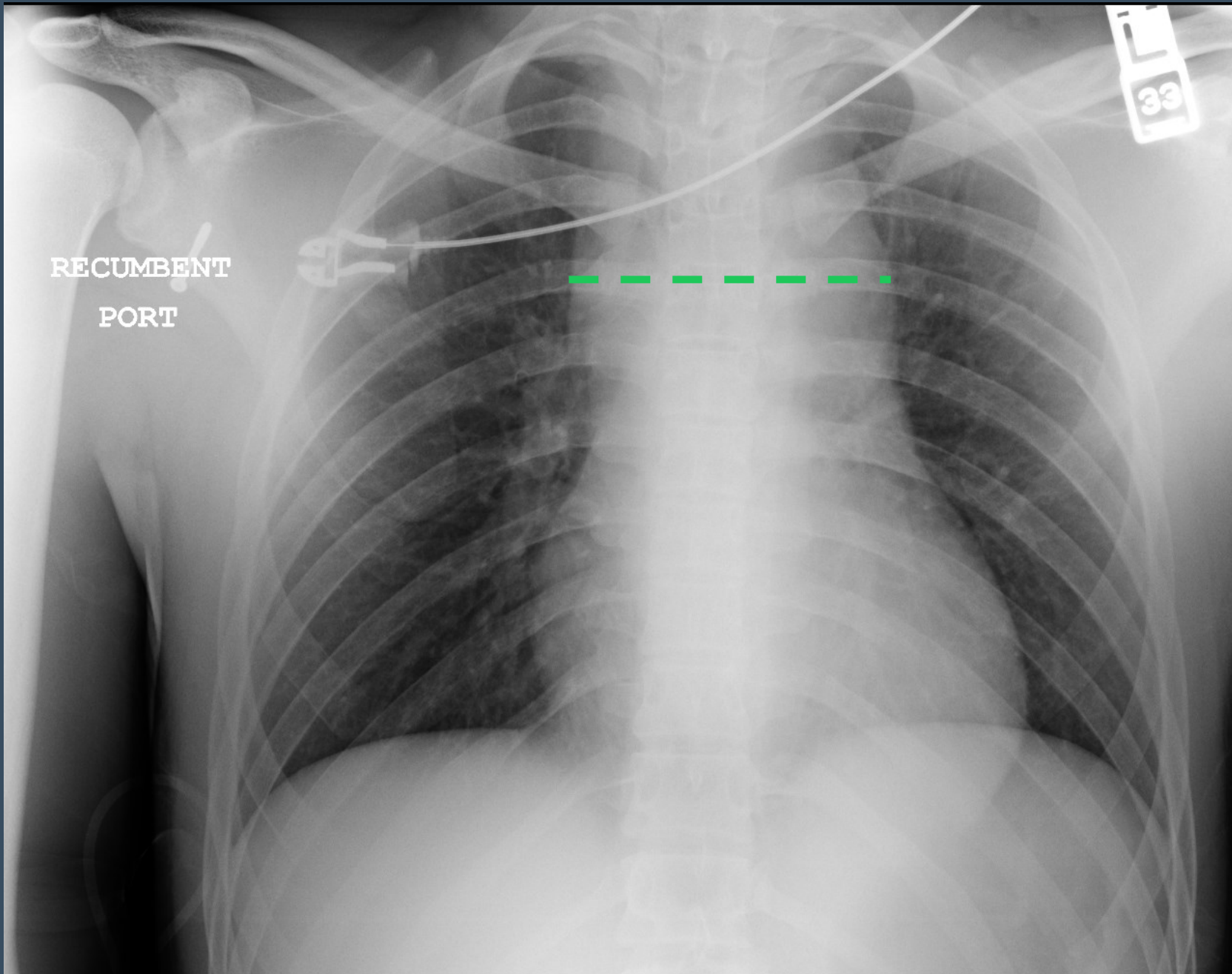
# CASE 1

History: Motor vehicle accident

Findings:

- Aortic pseudoaneurysm (→) immediately distal to left subclavian artery origin (→) at ligamentum arteriosum
- Mediastinal hematoma (→)





## CASE 2

History: 17-year-old motor vehicle accident

Findings:

- Wide mediastinum (---)

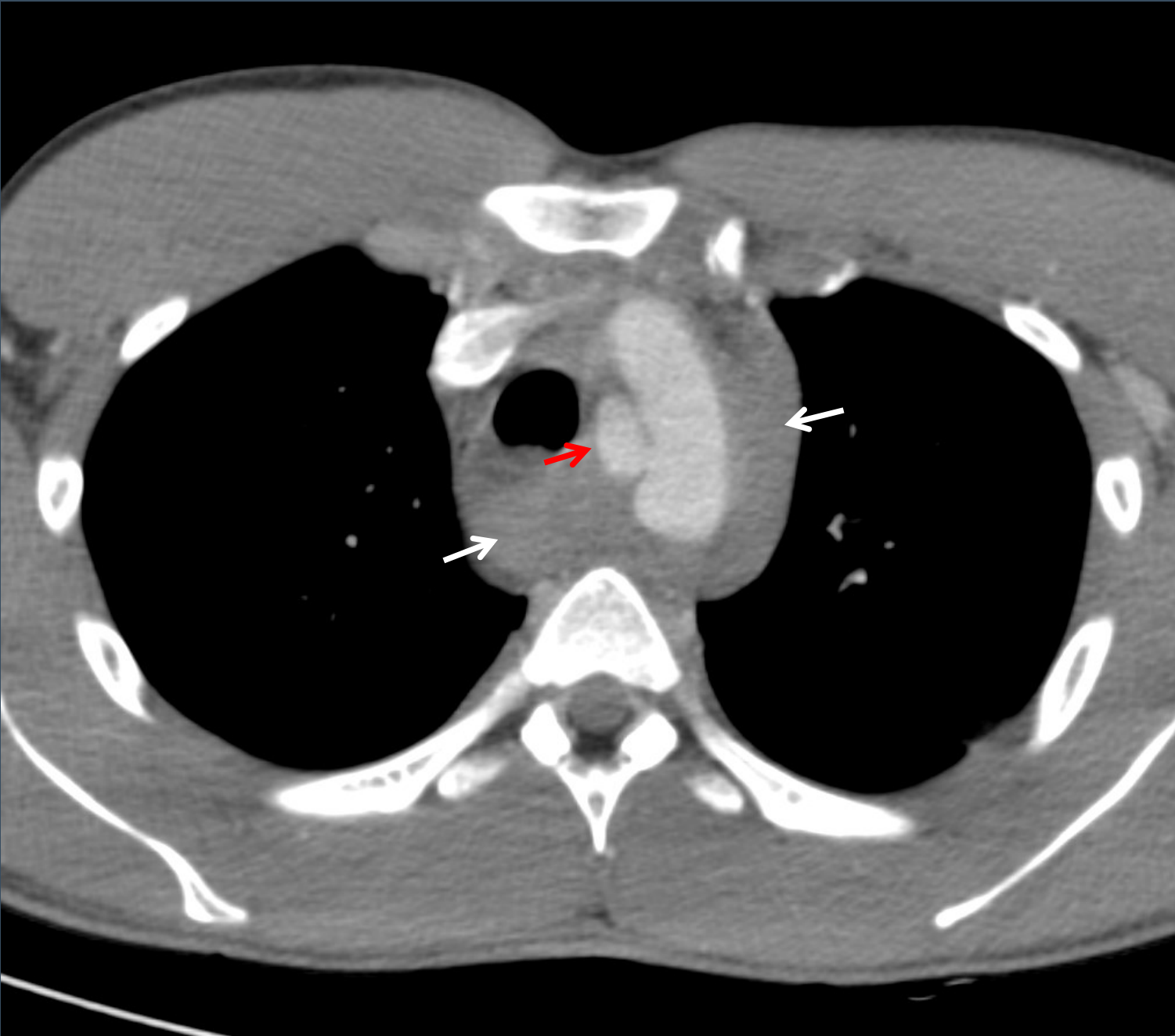


## CASE 2

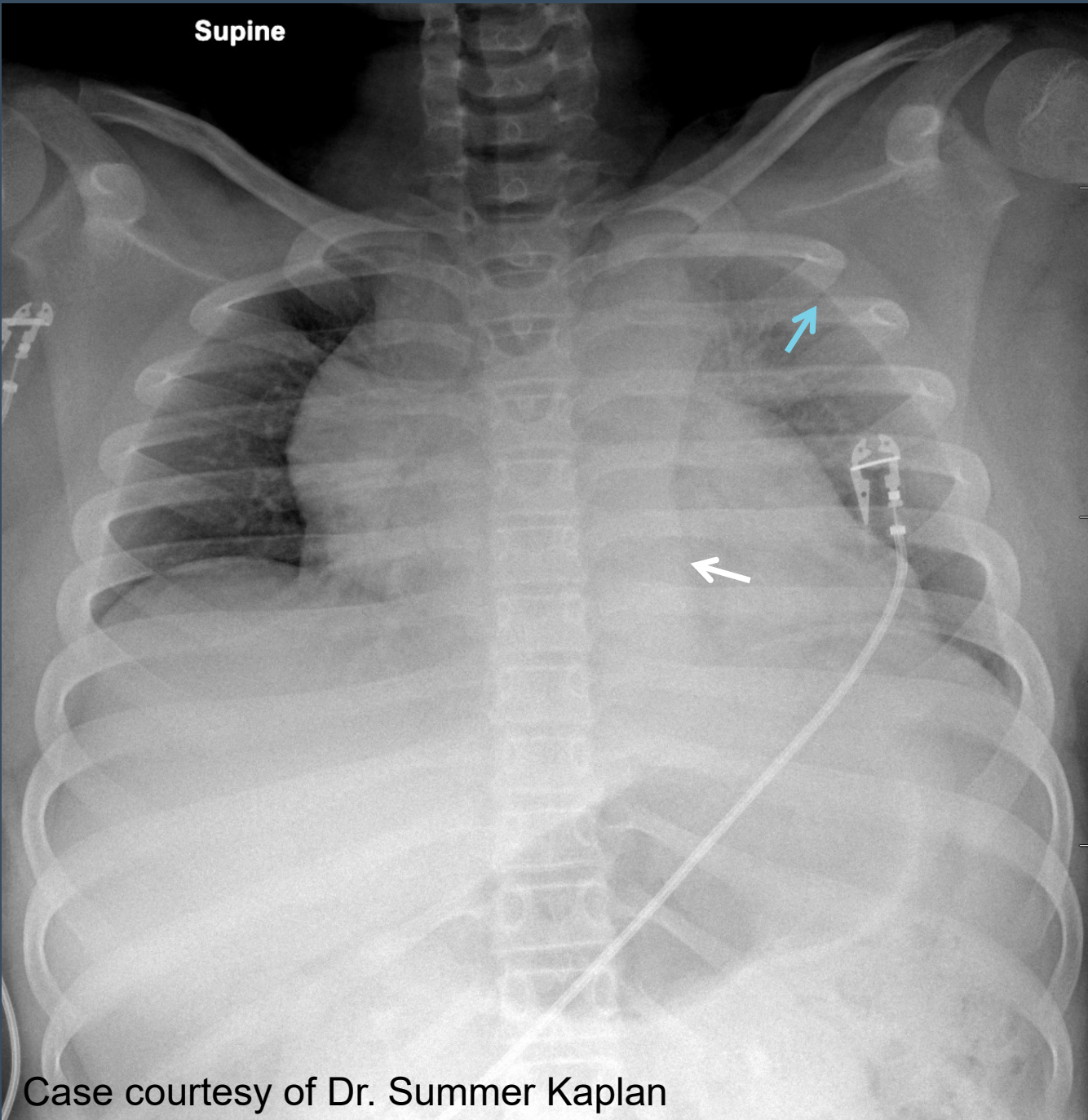
History: Pediatric patient motor vehicle accident

Findings:

- Aortic pseudoaneurysm (→) at ligamentum arteriosum
- Mediastinal hematoma (→)



Supine



## CASE 3

History: 11-year-old patient motor vehicle accident

Findings:

- Wide, dense paraspinal stripe (→)
- Small left pleural fluid (→)
- Indistinct aortic knob

Case courtesy of Dr. Summer Kaplan



## CASE 3

History: 11-year-old motor vehicle accident

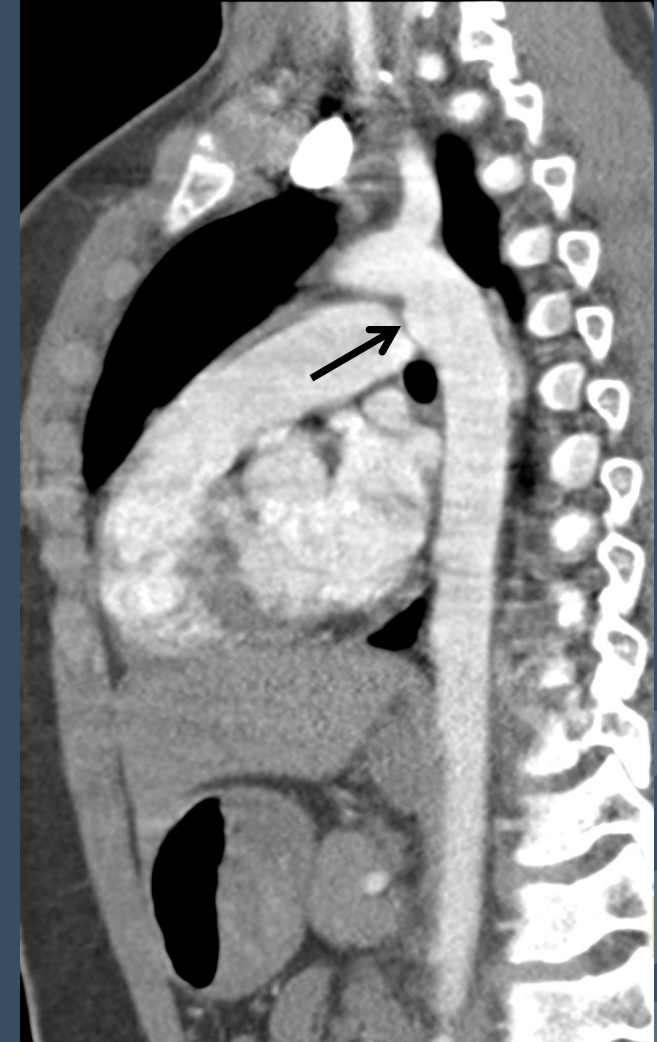
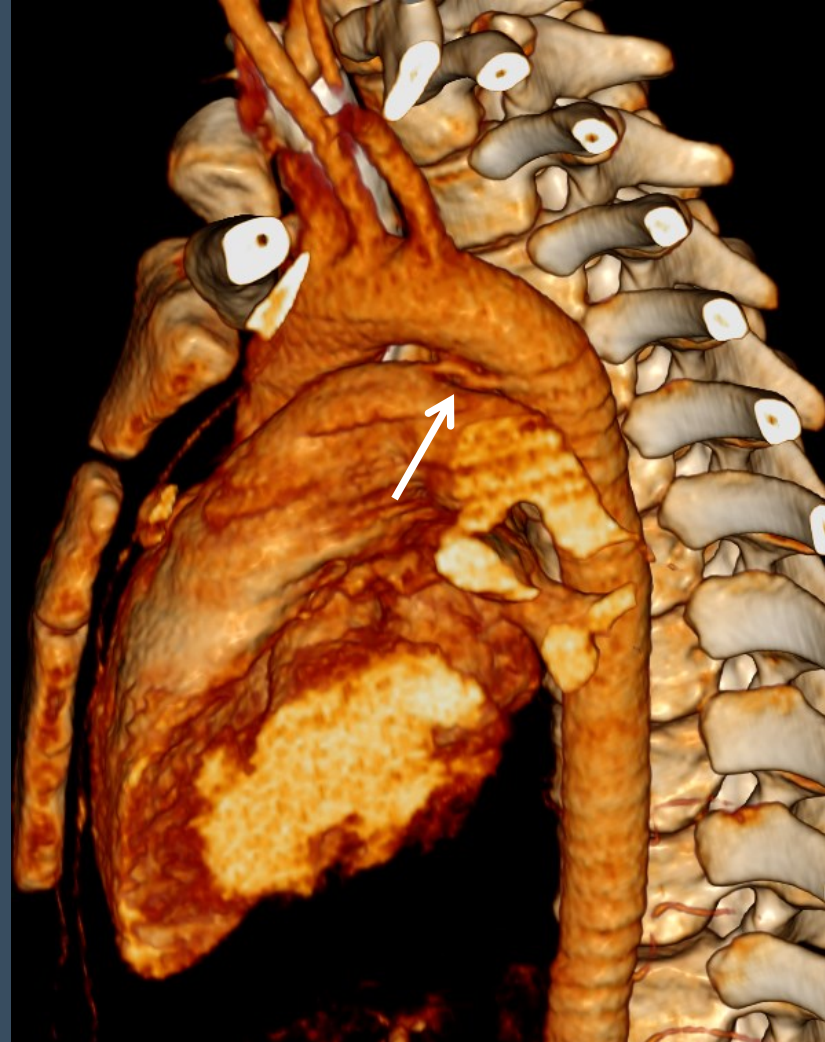
Findings:

- Aortic pseudoaneurysm (→) immediately distal to left subclavian artery origin (→) at ligamentum arteriosum
- Hematoma along descending aorta (→)



# Blunt Thoracic Aortic Injury

- Epidemiology
  - Rare, incidence 0.03%
  - >90% are >10 years of age
  - High overall mortality, 40%
- Mechanism
  - Aorta fixed distal to left subclavian artery origin at site of ligamentum arteriosum (→)
  - Prone to shearing forces
  - Thoracic compression
- Pitfall
  - Ductus diverticulum (→)





# Ductus Diverticulum



# Pseudoaneurysm

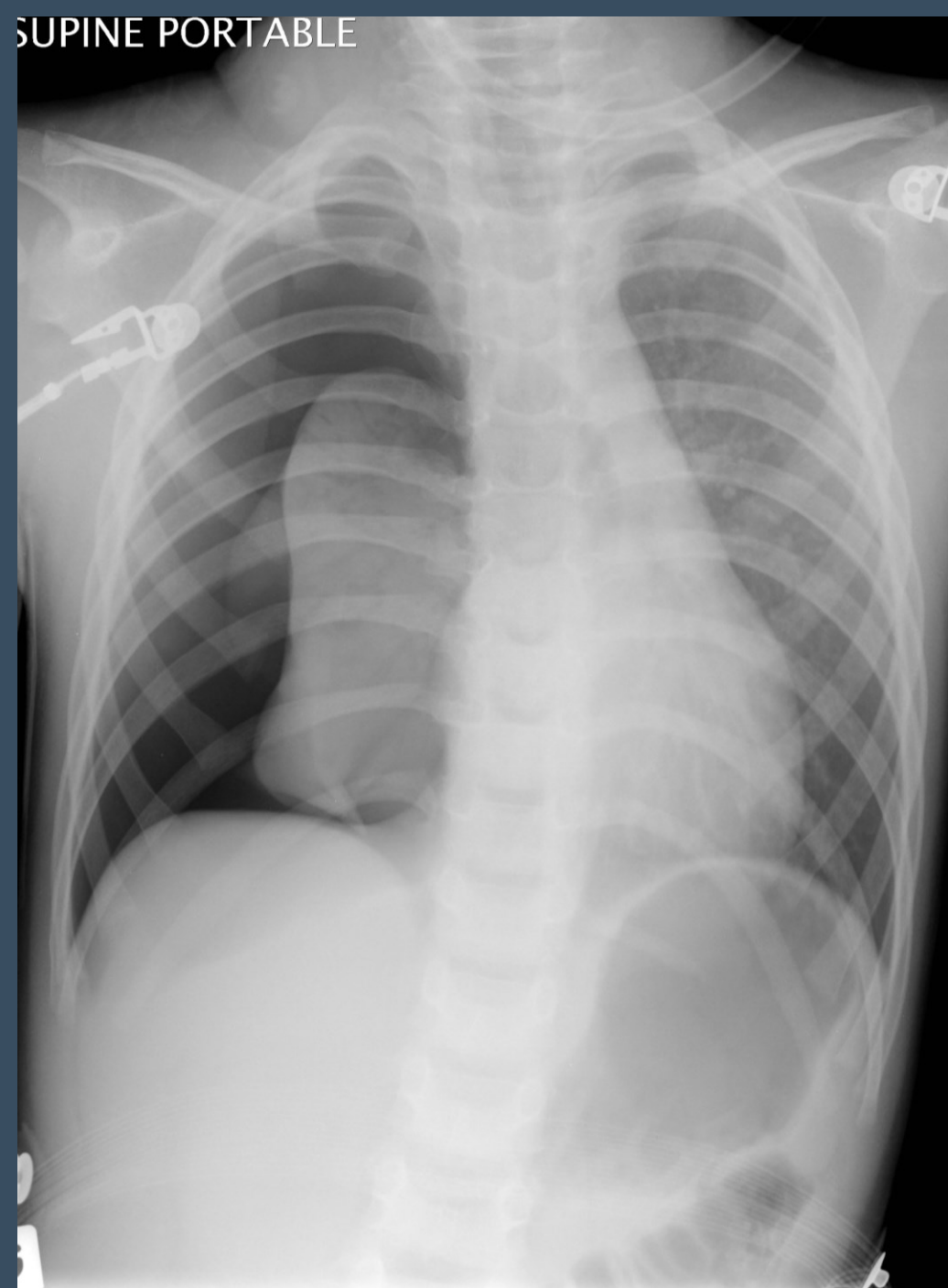


# Blunt Thoracic Aortic Injury

- Chest radiograph
  - Mediastinal widening
  - Apical cap
  - Prominent or indistinct aortic knob
  - Obliteration of aortopulmonary window
  - Wide paraspinal/paratracheal stripe
  - Fractures: first rib, sternum



SUPINE PORTABLE



## CASE 4

History: Pediatric patient with blunt trauma

Findings:

- Radiograph
  - Large pneumothorax
  - Lung collapse
- CT
  - Right lung at dependent aspect of thorax
  - Discontinuity of right bronchus (→)

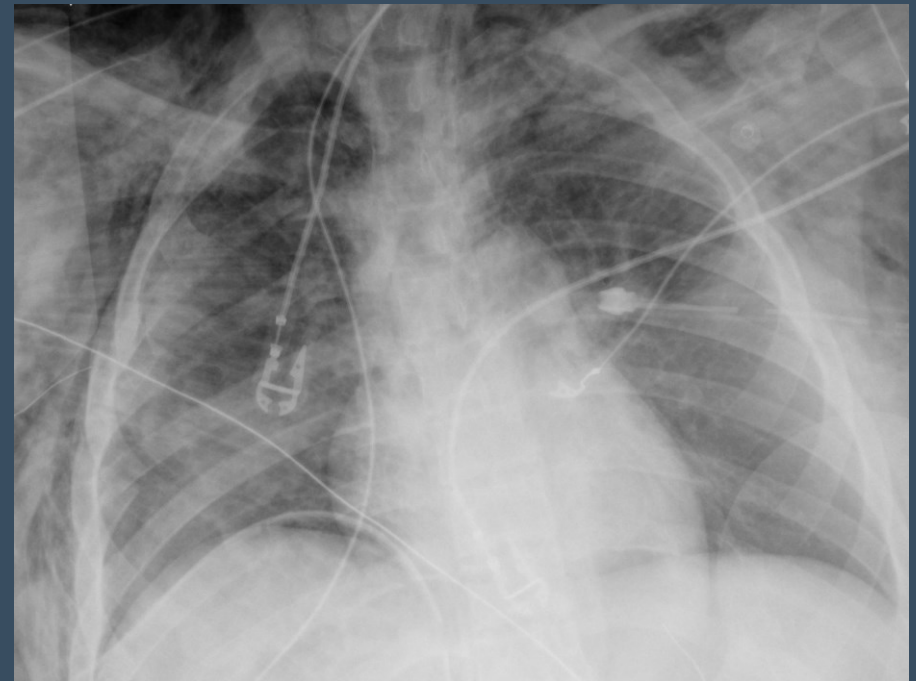


# CASE 5

History: Blunt trauma

Findings:

- Radiograph
  - Large pneumothorax
  - Pneumomediastinum
  - Soft-tissue emphysema
- CT
  - Discontinuity of right bronchus (→)



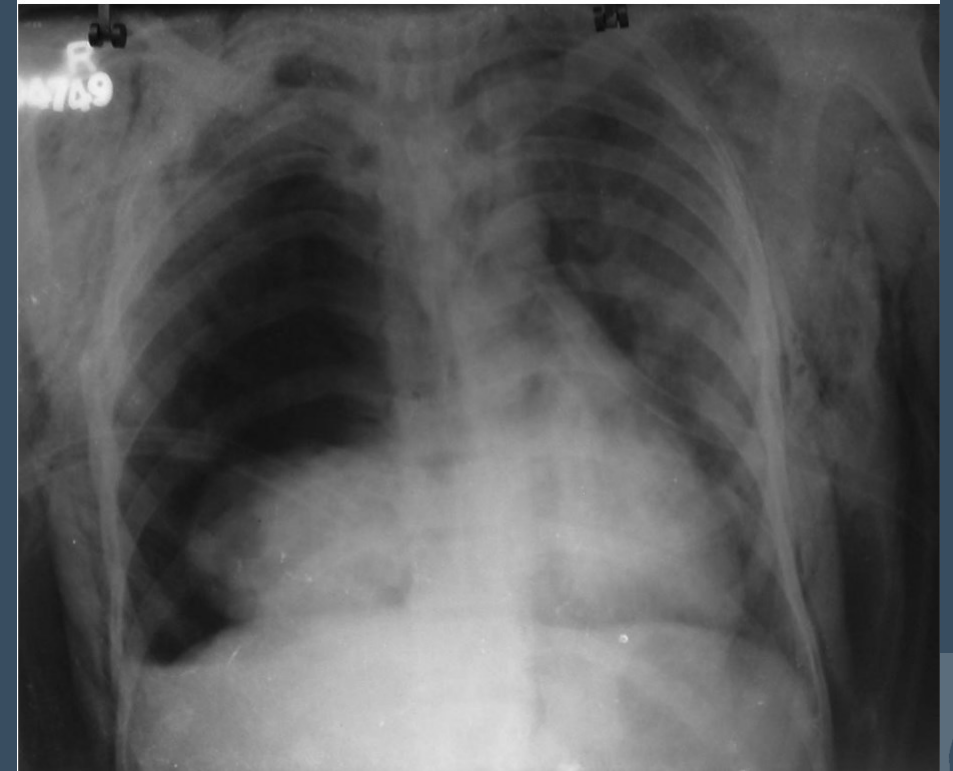
# Tracheobronchial Injury

- Rupture of major airway
  - >80% located 2.5 cm of carina
  - Most common at proximal right mainstem bronchus
- Epidemiology
  - Rare, 0.7% - 2.9%
  - High mortality, 30%
    - 50% within first hour
- Mechanism
  - Penetrating trauma
  - Compression of sternum against spine
  - ↑ Intrathoracic pressure against closed glottis



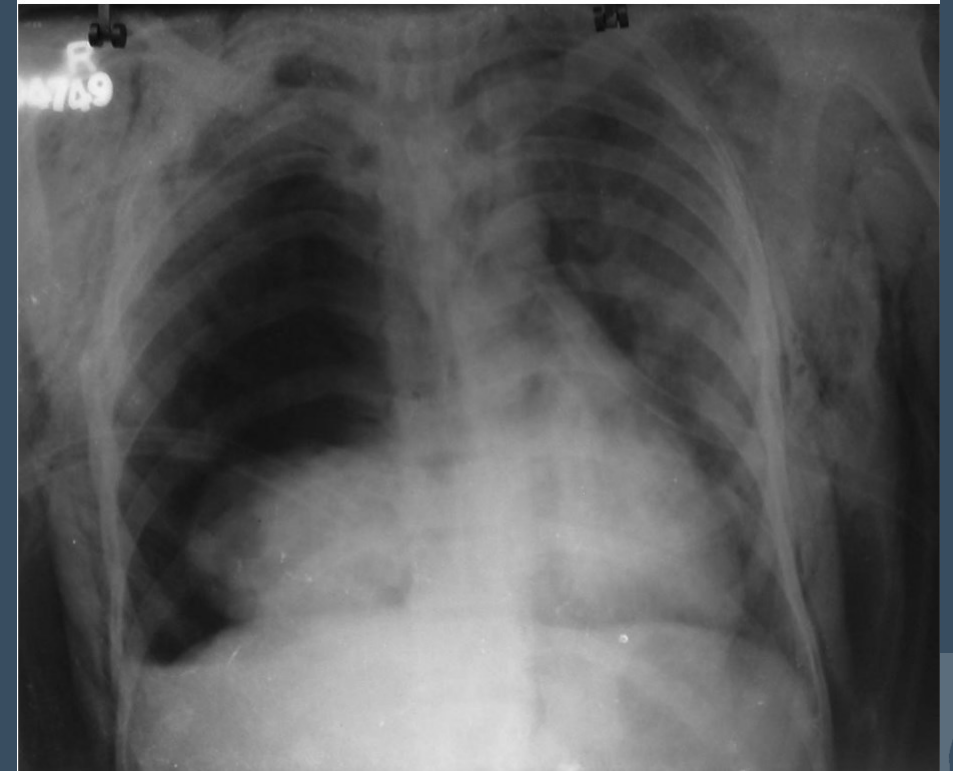
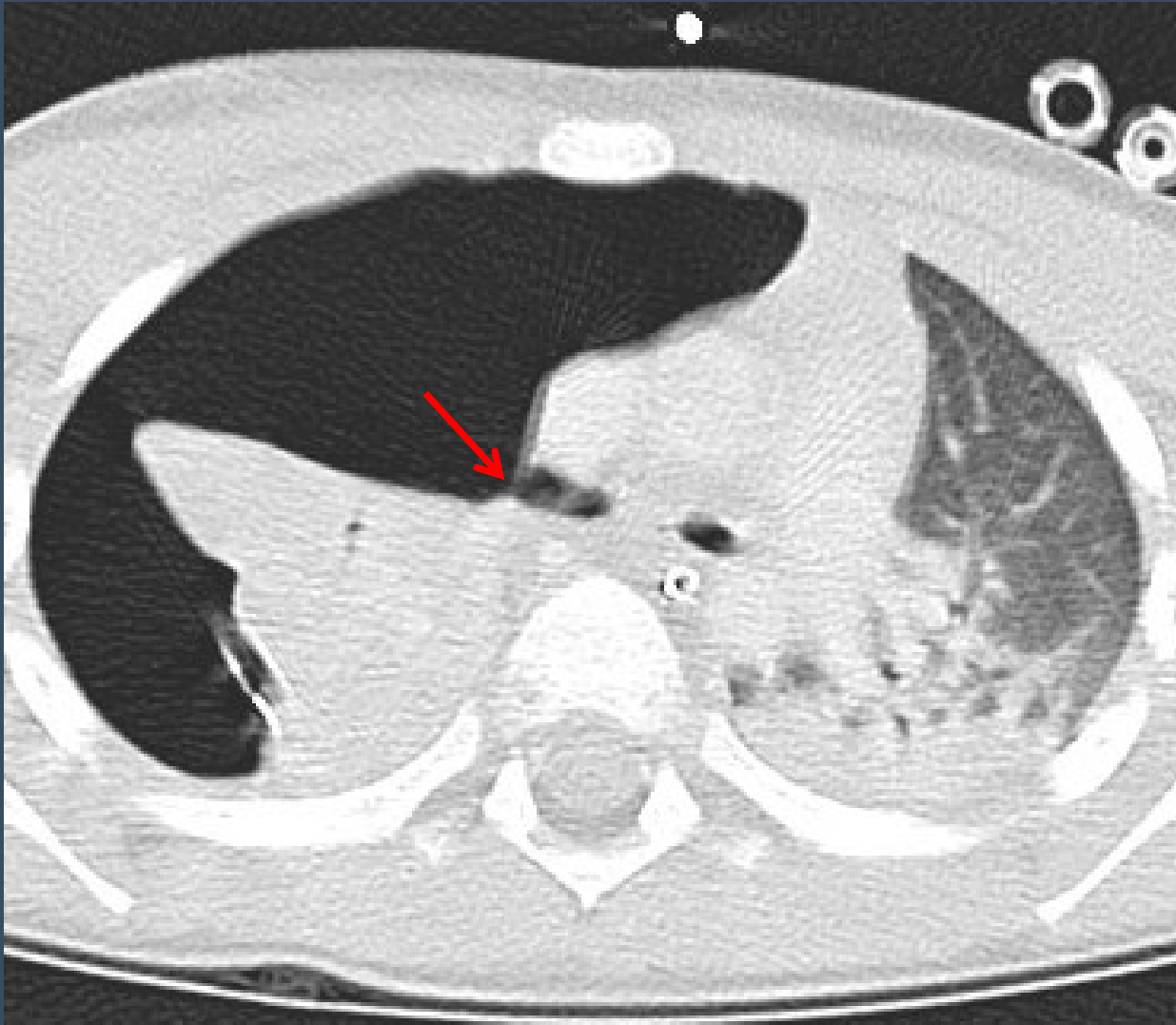
# Tracheobronchial Injury

- Clinical presentation
  - Difficult to diagnose clinically on presentation → delayed diagnosis
  - Non-specific radiographic findings
    - Pneumothorax
    - Pneumomediastinum
    - Rib fractures
  - Persistent pneumothorax despite well-functioning chest tube
- “Fallen lung” sign
  - Lung collapsed to dependent aspect of the thorax
  - Vascular pedicle unable to support weight of the lung



Magu S, Agarwal K, Lohchab SS, Agarwal S. Fallen Lung Sign (on Chest Radiograph). *Journal of Trauma and Acute Care Surgery*. 2011 Apr 1;70(4):1012.

# Tracheobronchial Injury



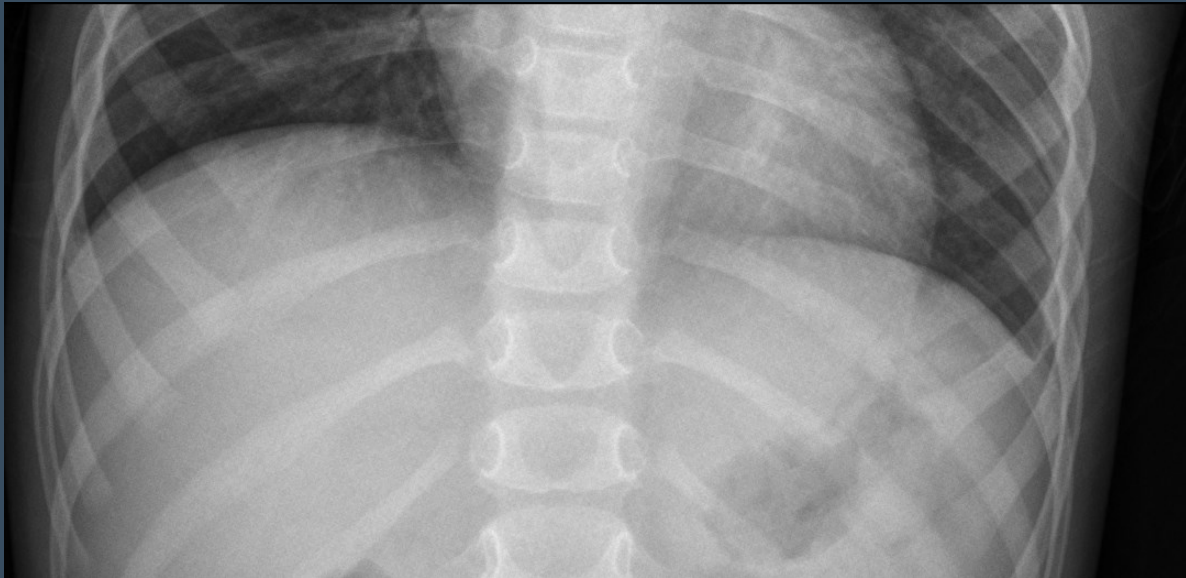
Magu S, Agarwal K, Lohchab SS, Agarwal S. Fallen Lung Sign (on Chest Radiograph). *Journal of Trauma and Acute Care Surgery*. 2011 Apr 1;70(4):1012.

# CASE 6

History: Pediatric patient with recent blunt trauma and new onset of vomiting

Findings:

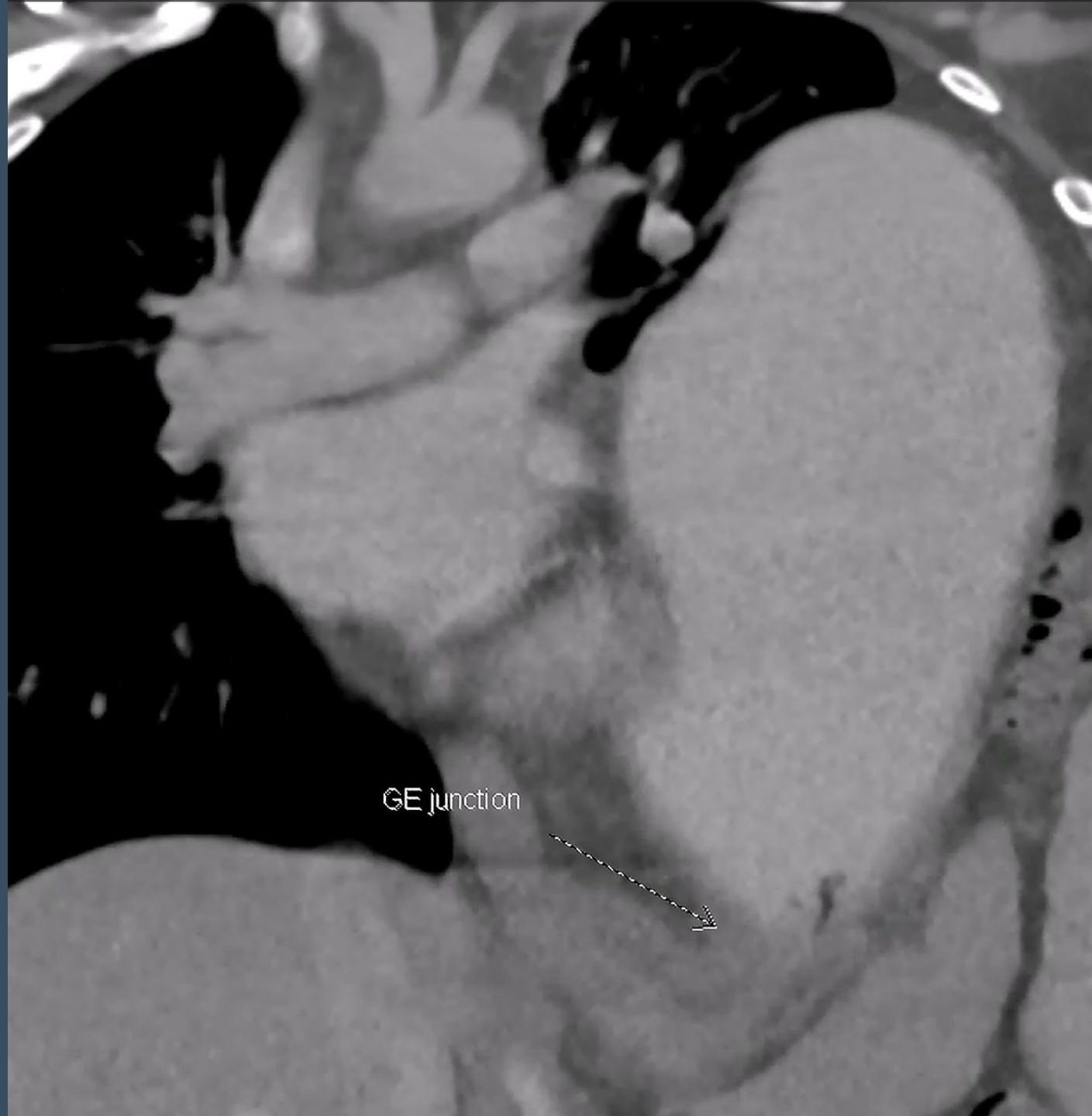
- Diaphragmatic hernia with intrathoracic bowel and stomach





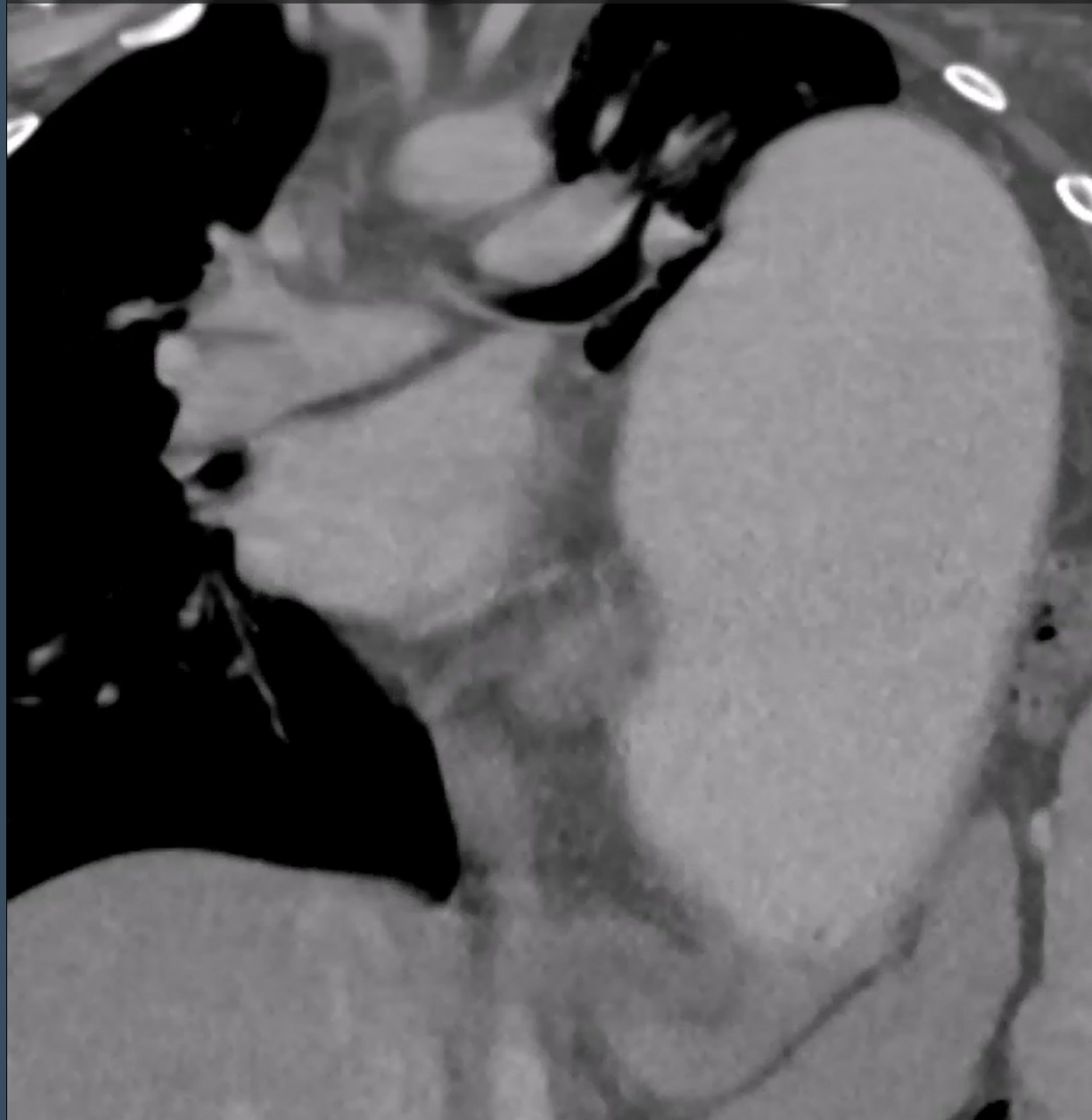
# CASE 6

History: Pediatric patient with recent blunt trauma and new onset of vomiting



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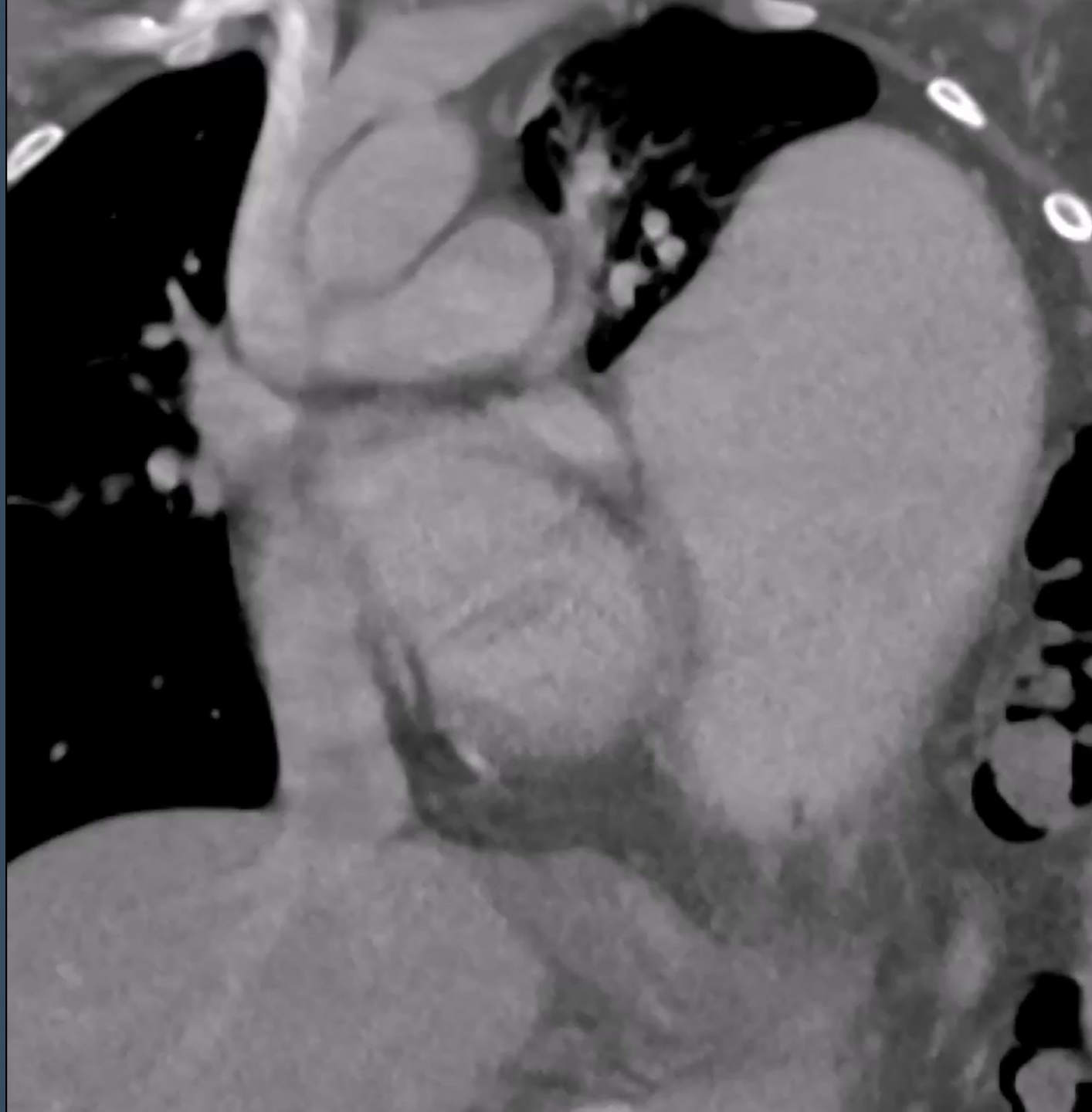
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History: Pediatric patient with recent blunt trauma and new onset of vomiting



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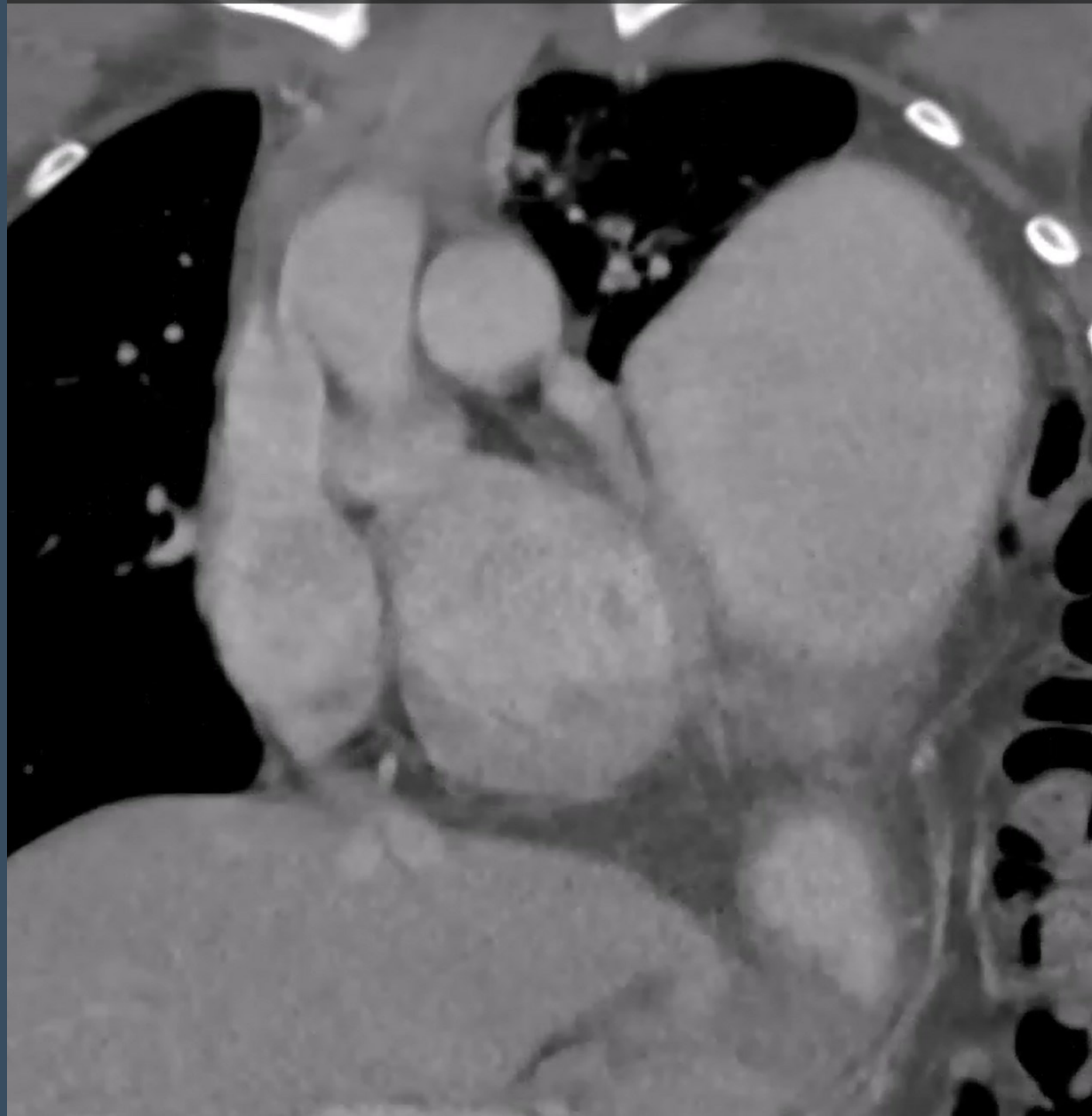
# CASE 6

History: Pediatric patient with recent blunt trauma and new onset of vomiting



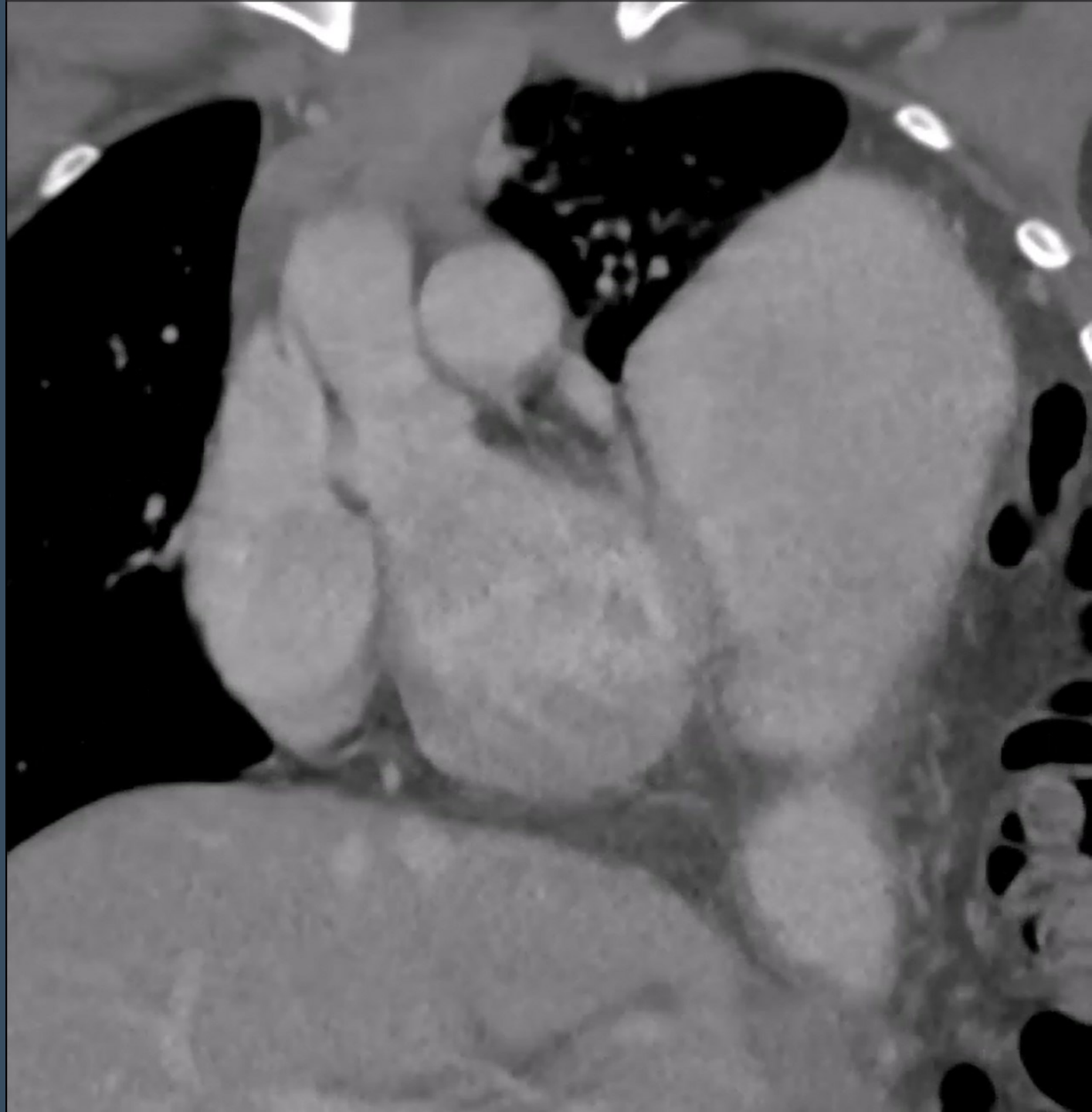
# CASE 6

History: Pediatric patient with recent blunt trauma and new onset of vomiting



# CASE 6

History: Pediatric patient with recent blunt trauma and new onset of vomiting



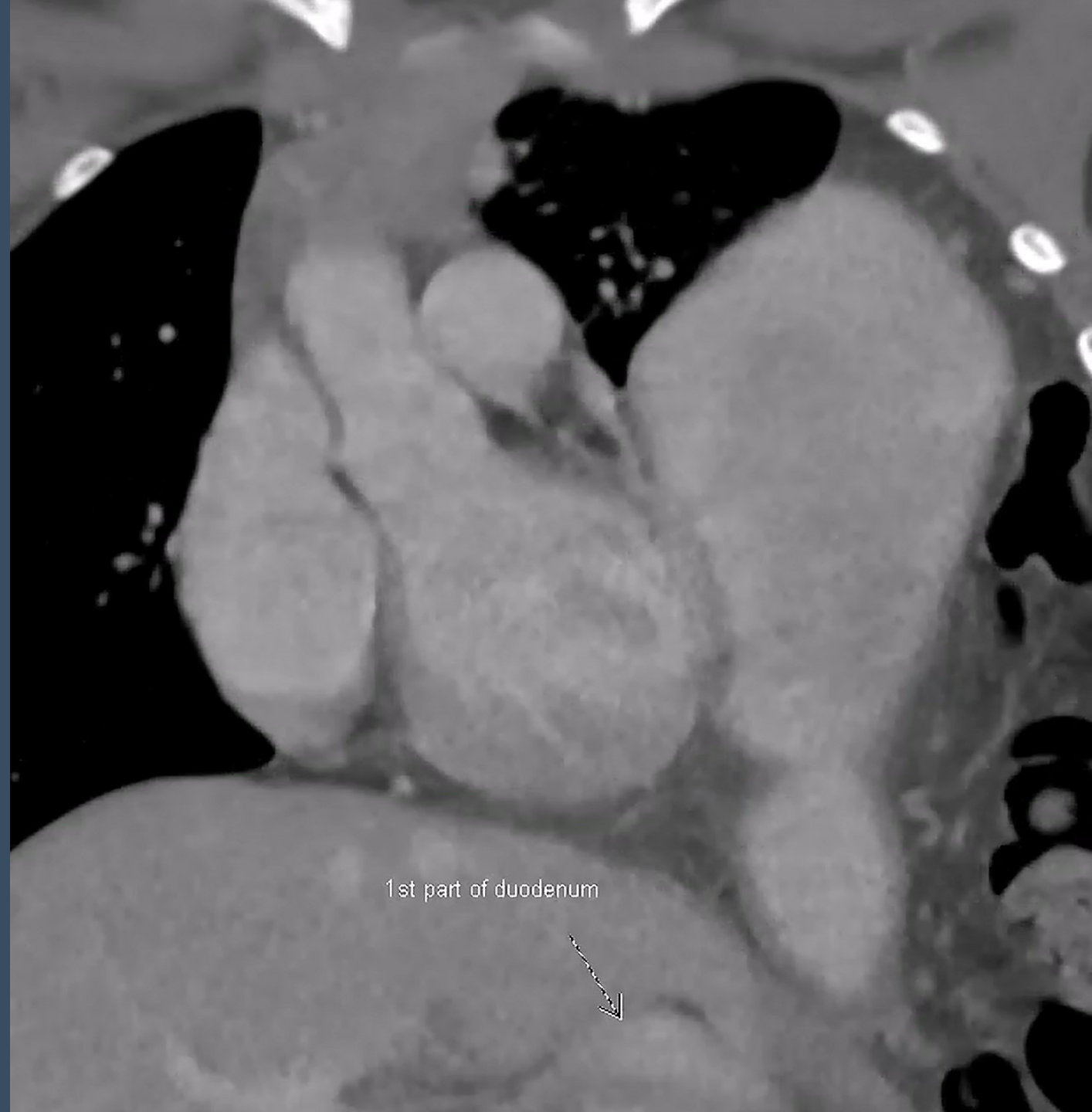


# CASE 6

History: Pediatric patient with recent blunt trauma and new onset of vomiting

Findings/ Impression:

- Delayed presentation of traumatic diaphragm rupture with hernia and mesenteroaxial gastric volvulus

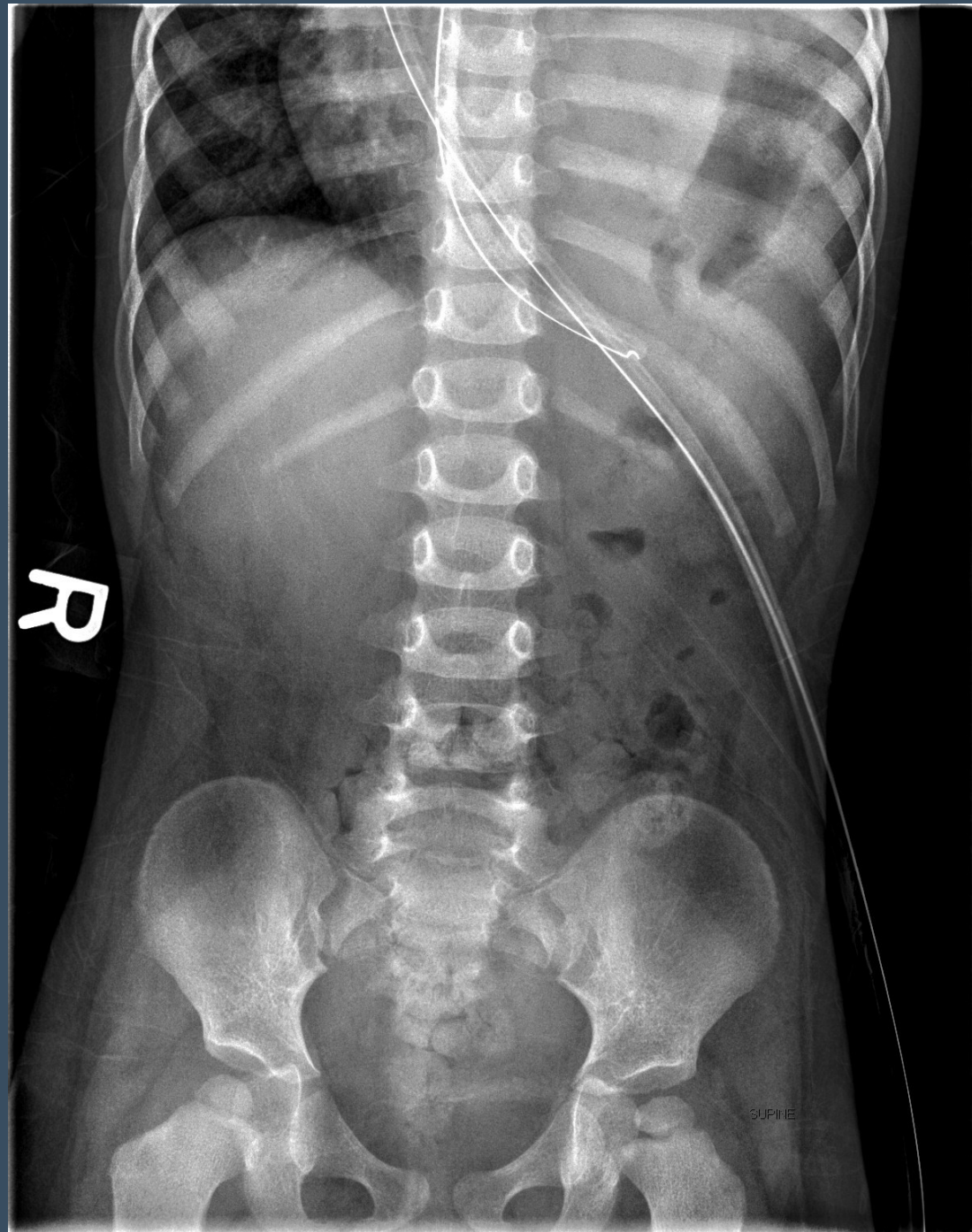


# CASE 7

History: Previous history of motor vehicle collision now with abdominal pain.

Findings:

- New left diaphragmatic hernia



# CASE 7

History: Previous history of motor vehicle collision now with abdominal pain.

Findings:

- Delayed presentation of traumatic diaphragm rupture with hernia and mesenteroaxial gastric volvulus



# Traumatic Diaphragmatic Hernia

- Epidemiology
  - Rare, prevalence 0.07%
  - Delayed diagnosis >12 hours in >50%
- Imaging
  - 30% of initial chest radiographs are negative
  - CT Sn & Sp > 70%
- Clinical presentation
  - Polytrauma
  - Respiratory distress, abdominal pain
  - May present with mesenteroaxial volvulus

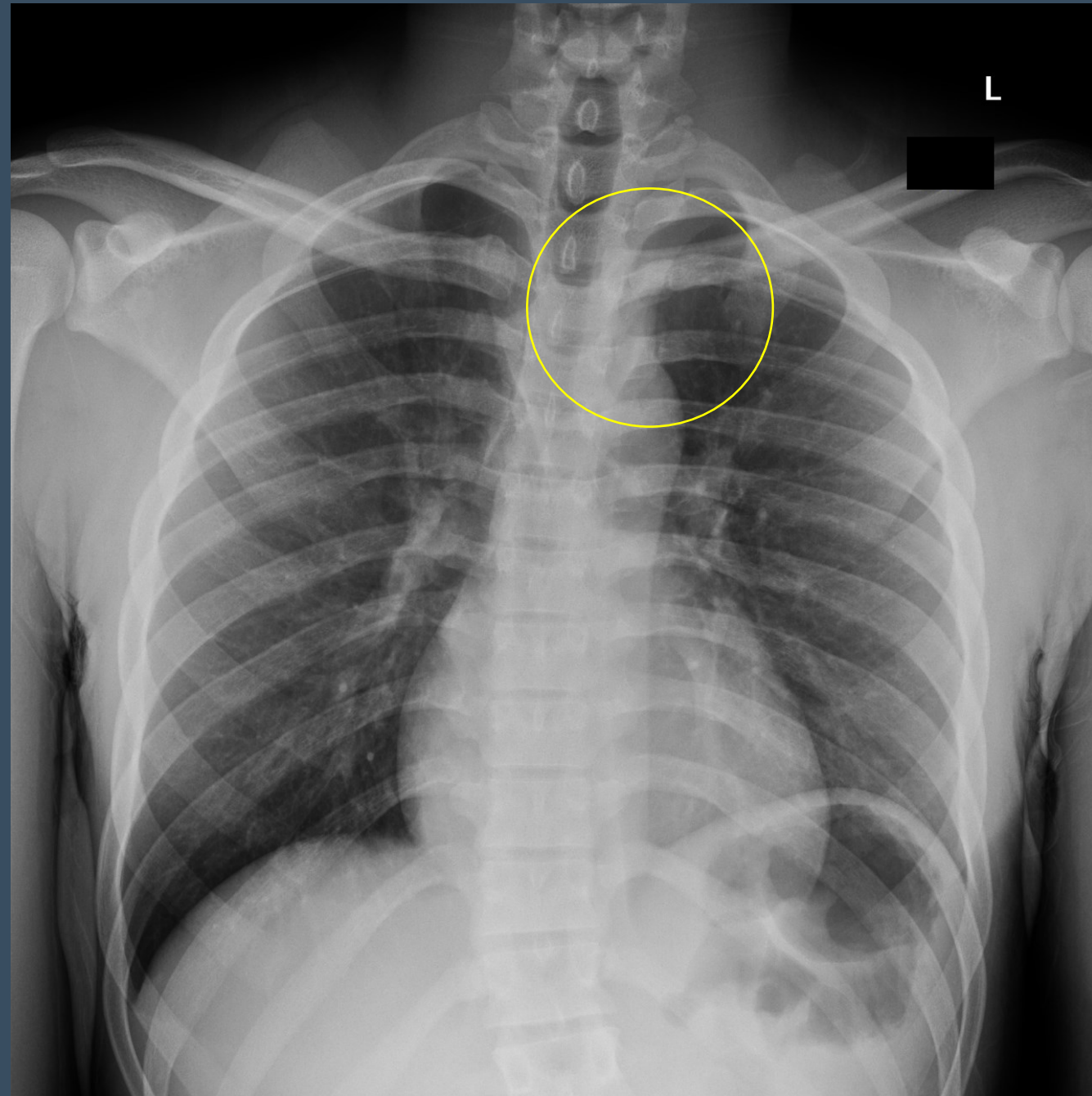
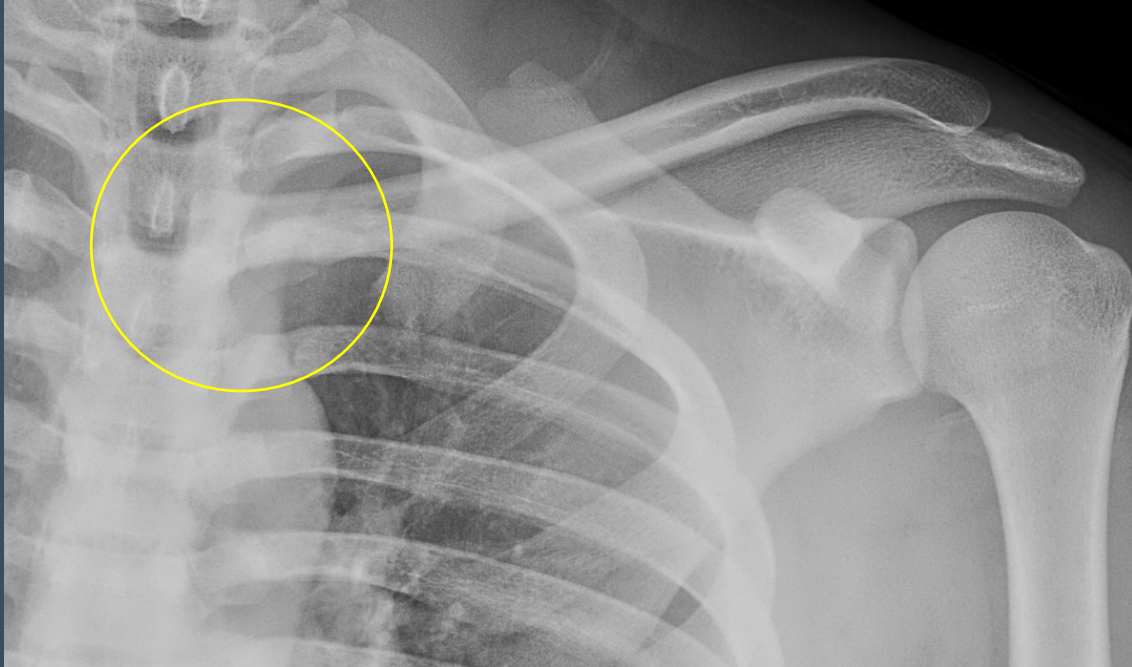


# CASE 8

History: 17-year-old with chest and shoulder pain after football injury

Findings:

- Left sternoclavicular dislocation



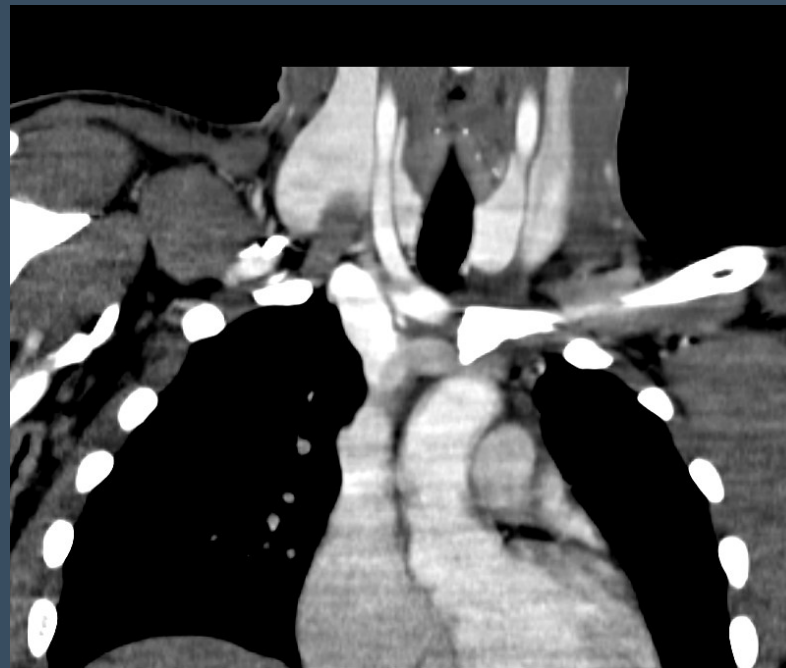
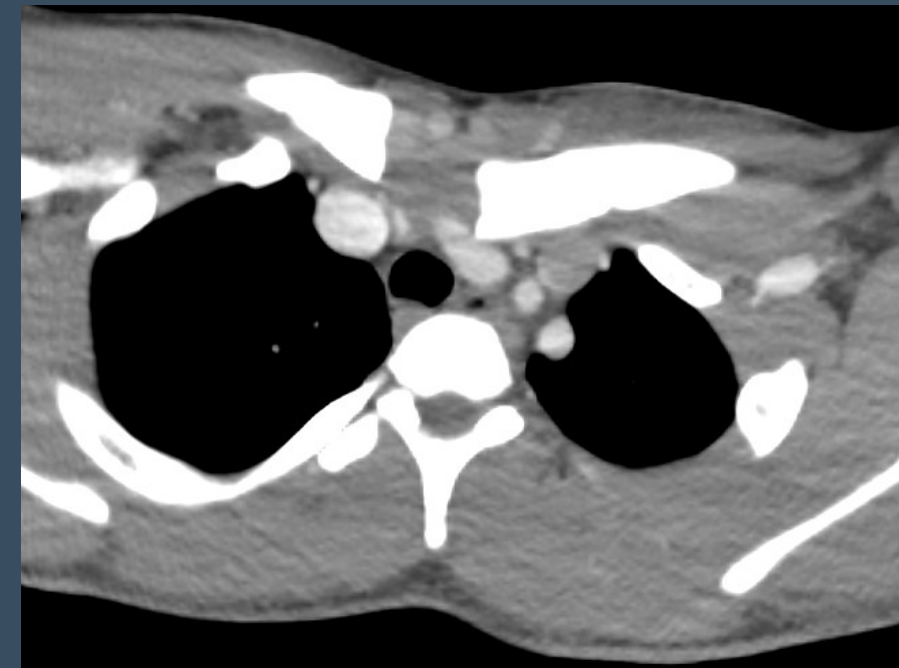
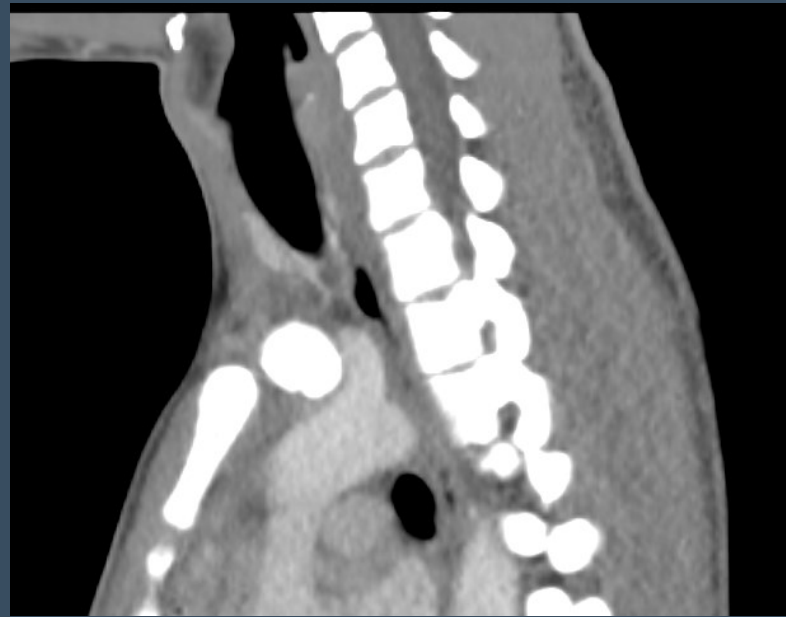
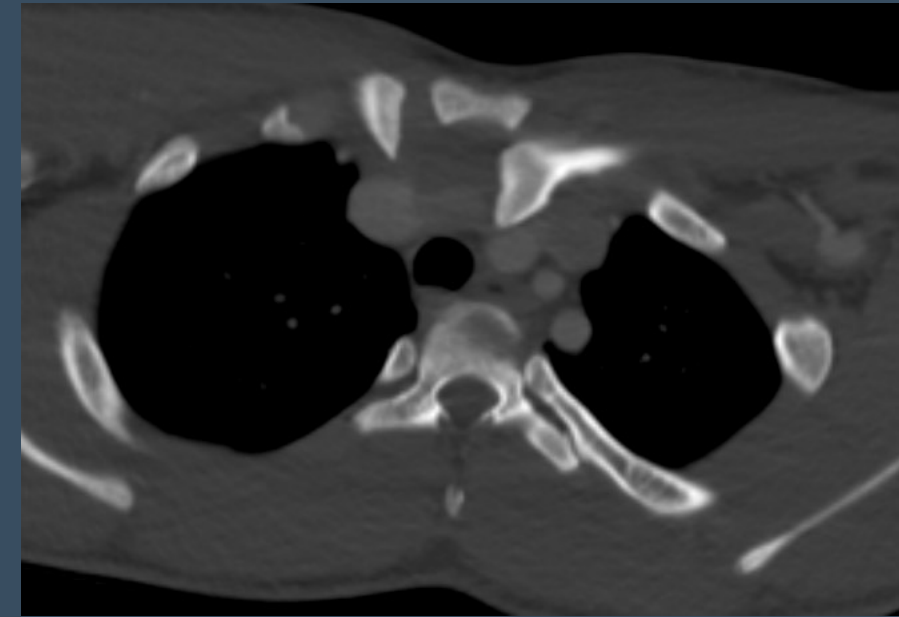
## CASE 8

History: 17-year-old with chest and shoulder pain after football injury

Findings:

- Left sternoclavicular dislocation
- Mass effect on left brachiocephalic vein without arterial injury

Posterior sternoclavicular dislocation, sternal and scapular fractures can be associated with vascular and cardiac injury



# CASE 9

## History:

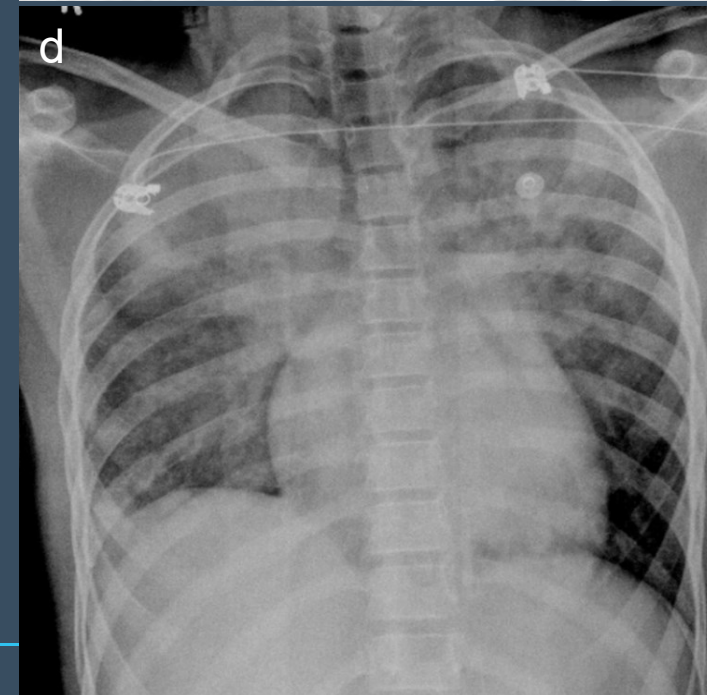
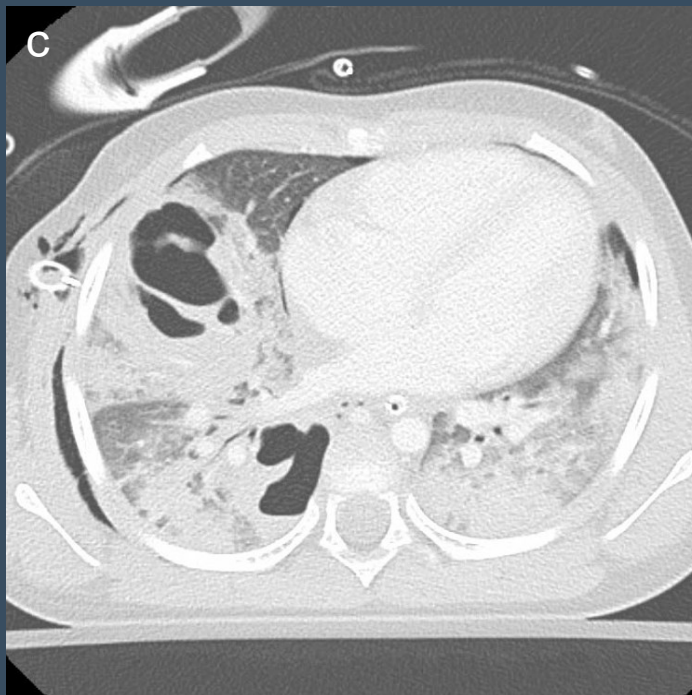
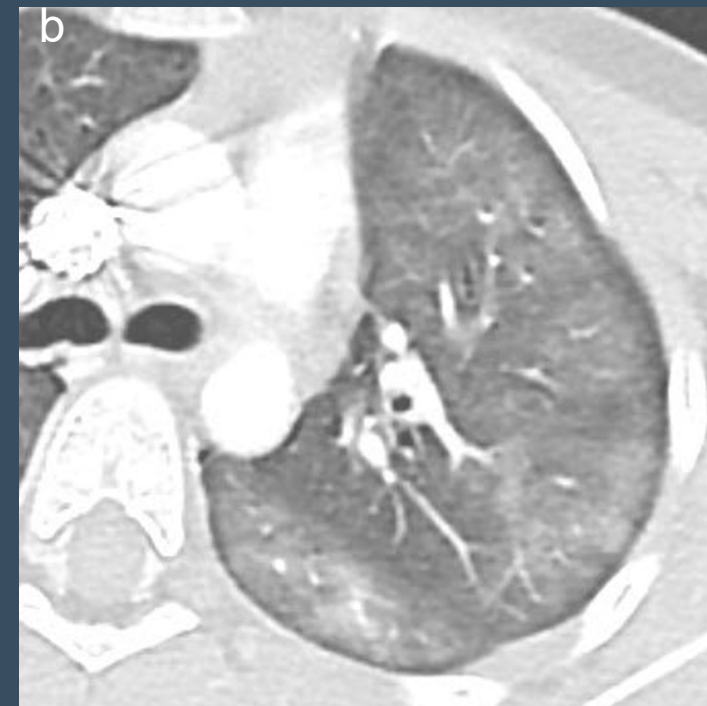
- a) 9-year-old, bike accident
- b) 6-year-old, run over by car
- c) 3-year-old, run over by car
- d) 11-year-old, stepped on by horse

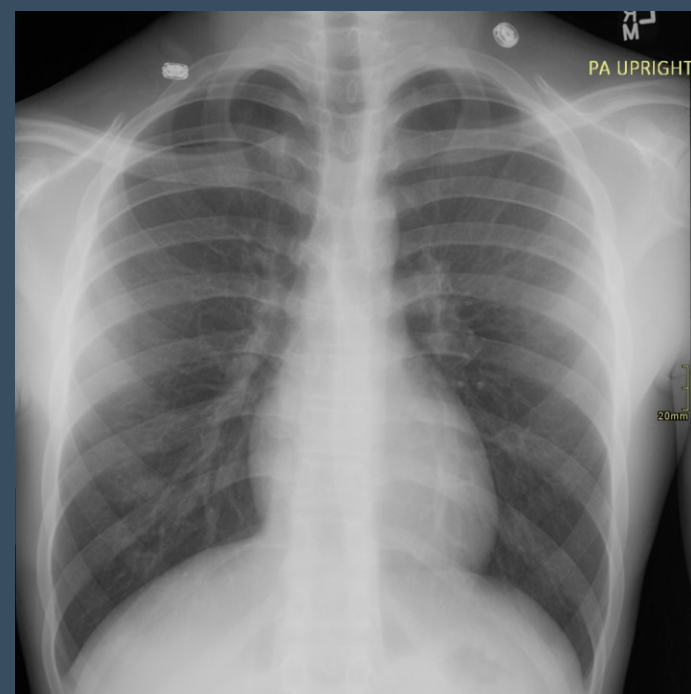
## Contusion

- Opacities at site of impact or contrecoup injury
- Subpleural sparing
- May not respect fissures
- May not be evident on radiographs in first 4-6 hours, clear in 7-10 days

## Laceration

Thin-walled cyst  $\pm$  air-fluid level

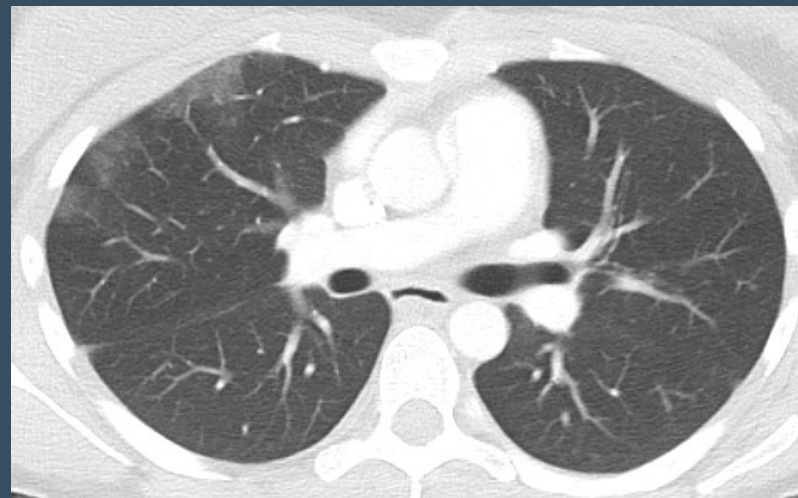




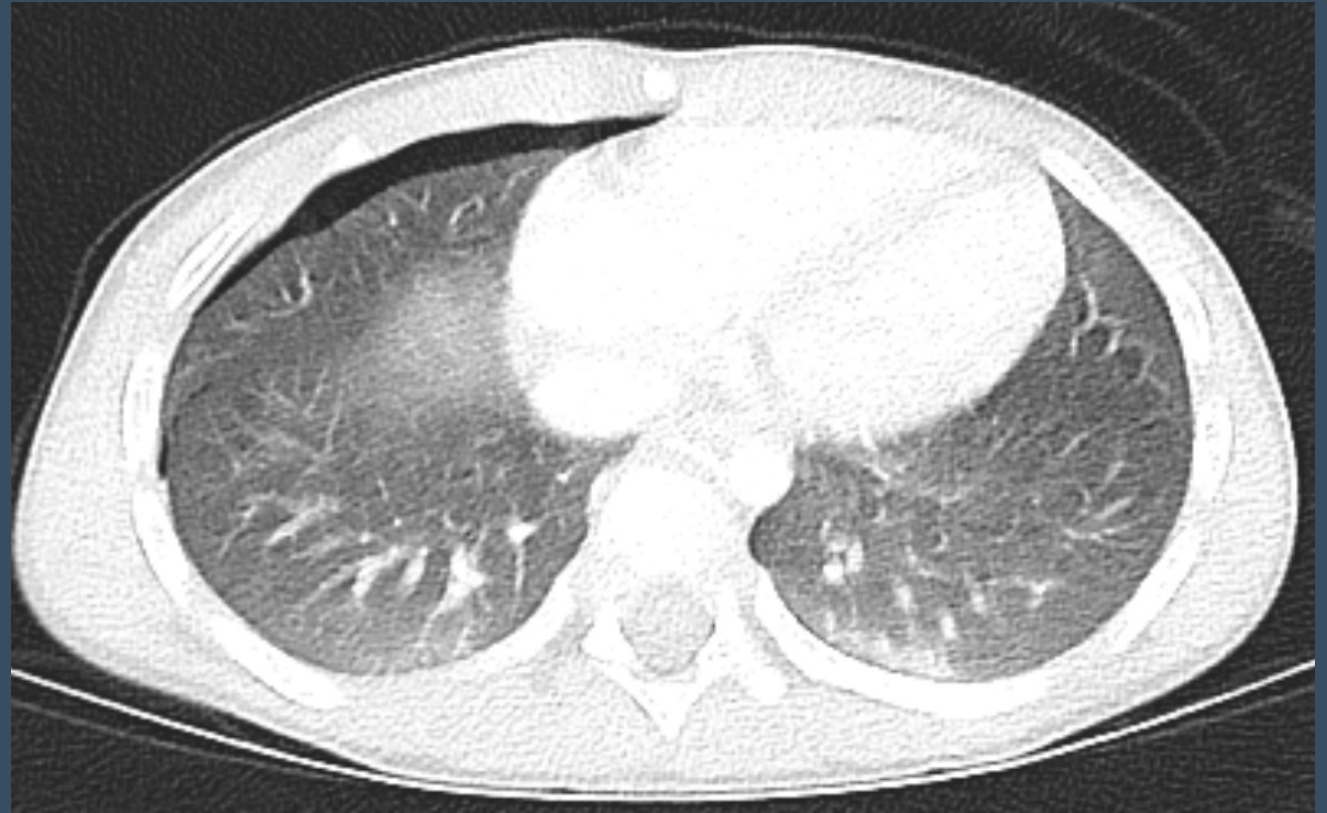
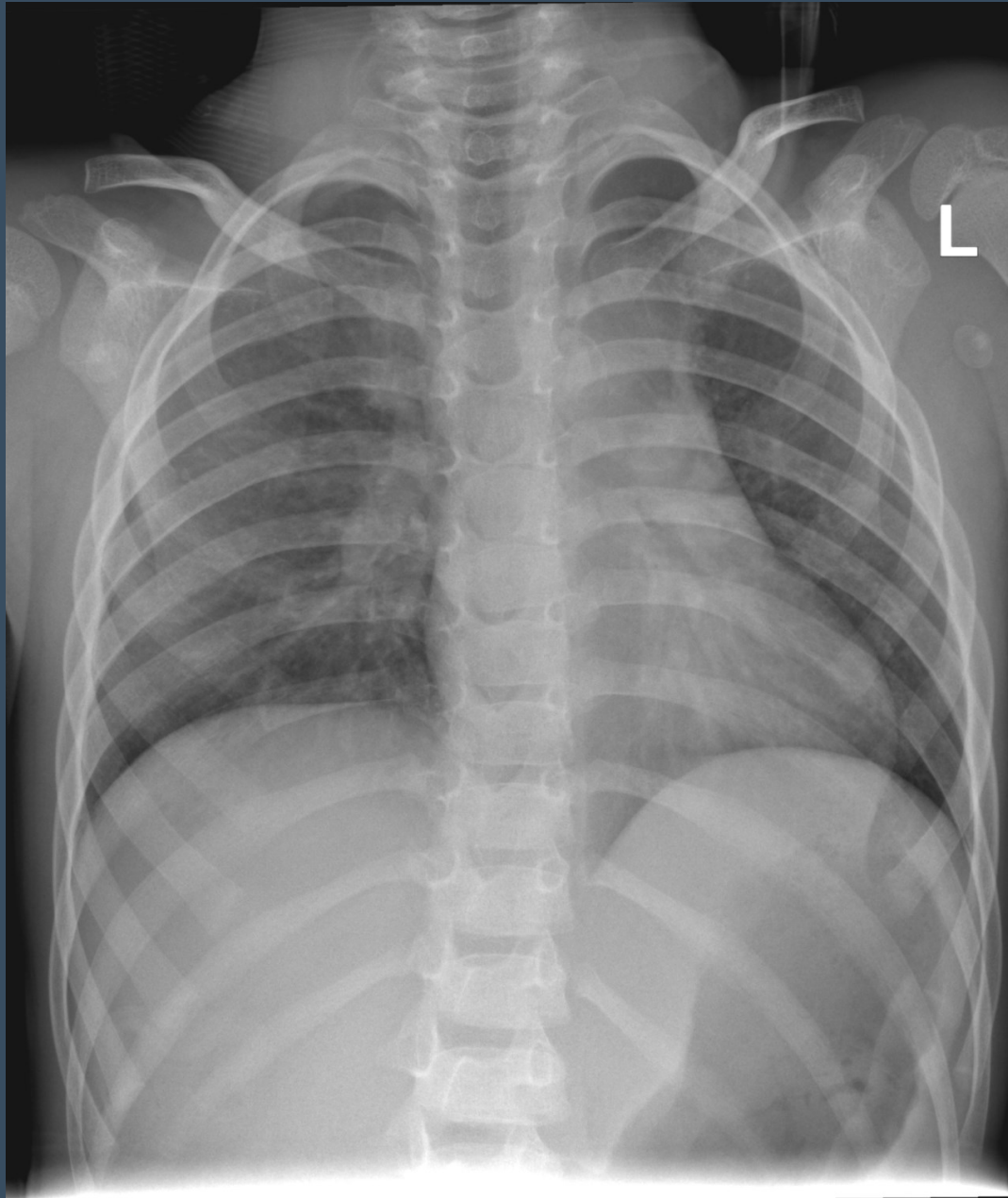
## CT vs Radiograph

Sensitivity CT > Radiograph

Pulmonary contusion seen only on CT does not change management







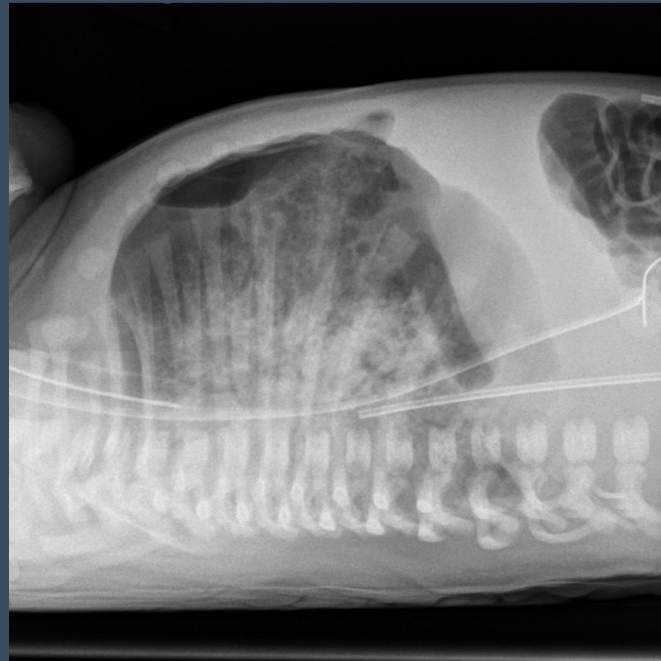
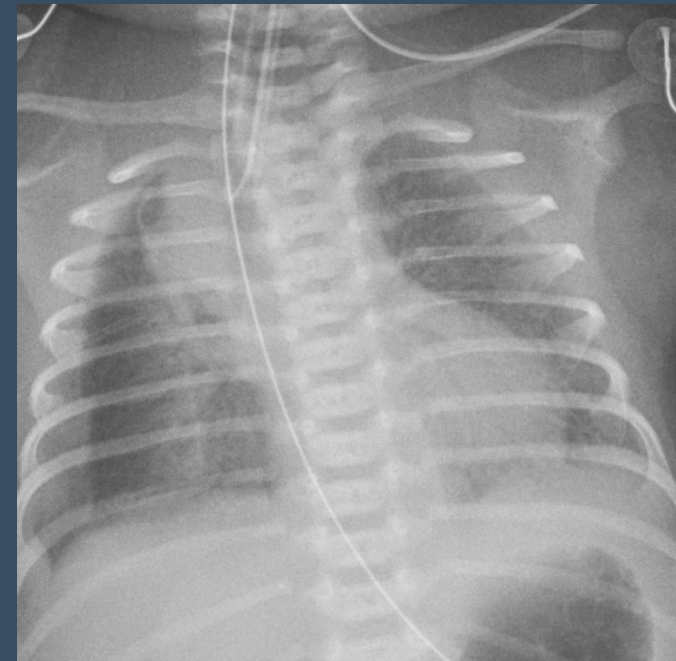
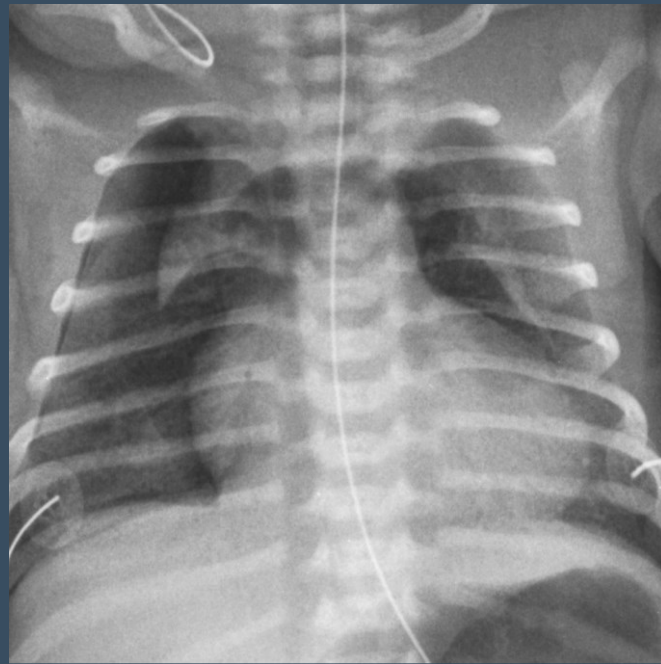
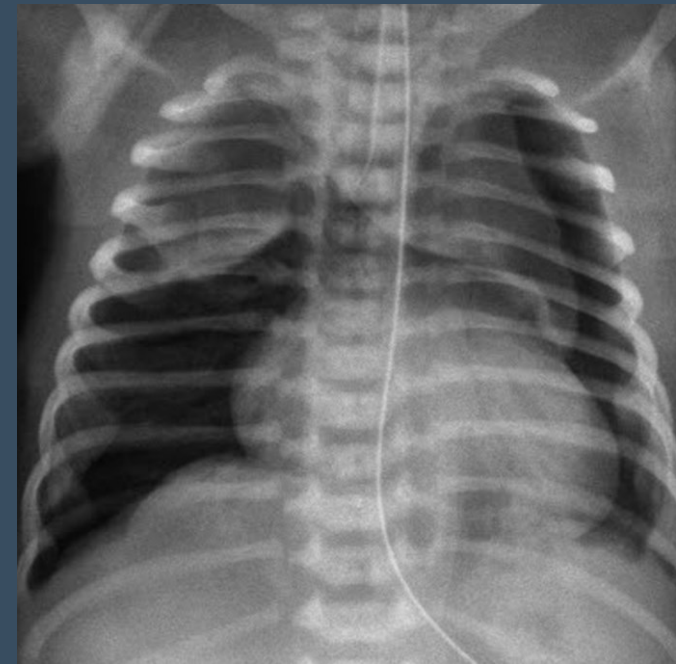
## CT vs Radiograph

Sensitivity CT > Radiograph

Small pneumothorax not identified on radiograph  
rarely changes management

# Pneumothorax & Pneumomediastinum

- Most patients imaged supine
- Air collects at nondependent aspect of chest
- Pneumomediastinum
  - Air lifts lobes of the thymus, sail sign
  - Distinguish from normal thymic contour
- Pneumothorax
  - Air collects anterior and medial
  - Pleural line may not be seen
  - Vague, medial, or basilar hyperlucency
  - Deep sulcus sign
  - Decubitus or cross-table lateral views helpful



# Take Home Points

- Chest radiograph is a useful screening study in the setting of blunt chest trauma
- Proceed to CTA if concern for vascular injury
- Other findings seen only on CT rarely change management

