THORACIC TRAUMA (non-vascular)

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THORACIC TRAUMA

Timing of MDCT in Lausanne (CHUV)

- **Cerebral, cervical, thoracic and abdominal**
- **Average < 55 minutes**
  - **Transportation and installation: 18 min**
  - **CT data acquisition: 14 min**
  - **Data management (2-D, 3-D): 8 min**
  - **Radiologist interpretation: < 15 min**

Wintermark and Schnyder 2003

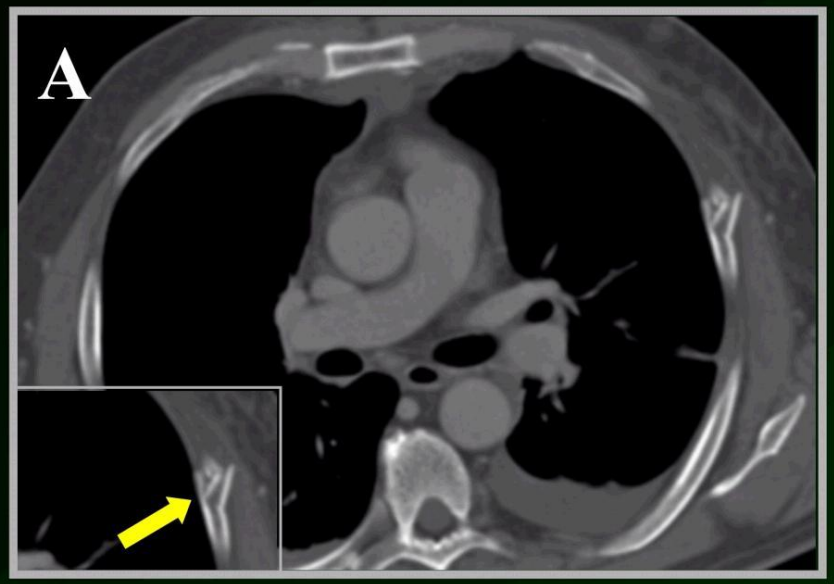
THORACIC TRAUMA
MDCT

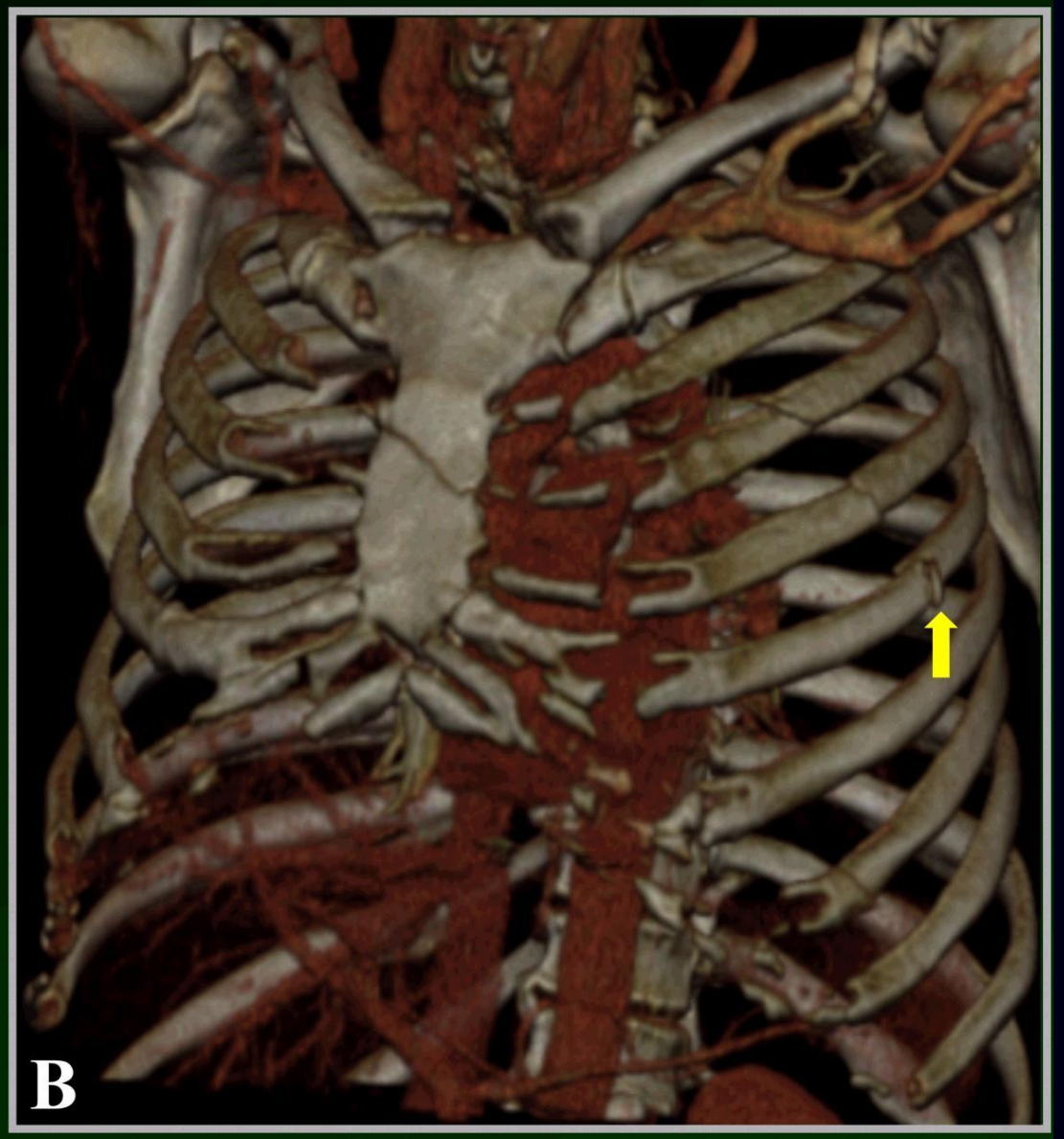
- **2-D and 3-D are mandatory**
  - **informations for referring physicians**
  - **diagnosis:**
    - **flail chest, sternal and spine #**
    - **diaphragmatic rupture**
    - **tracheobronchial injuries**
    - **aortic injuries**

Wintermark and Schnyder 2003

Osseous injuries
Rib fractures

- 50 % of blunt trauma
- Often undiagnosed at admission (nondisplaced, chondrosternal separation)
- Complications:
  - Hemothorax or extrapleural hematoma
  - Lung contusion or laceration
  - Pneumothorax and parietal emphysema
  - Flail chest





Chavarri E et al. ECR 2004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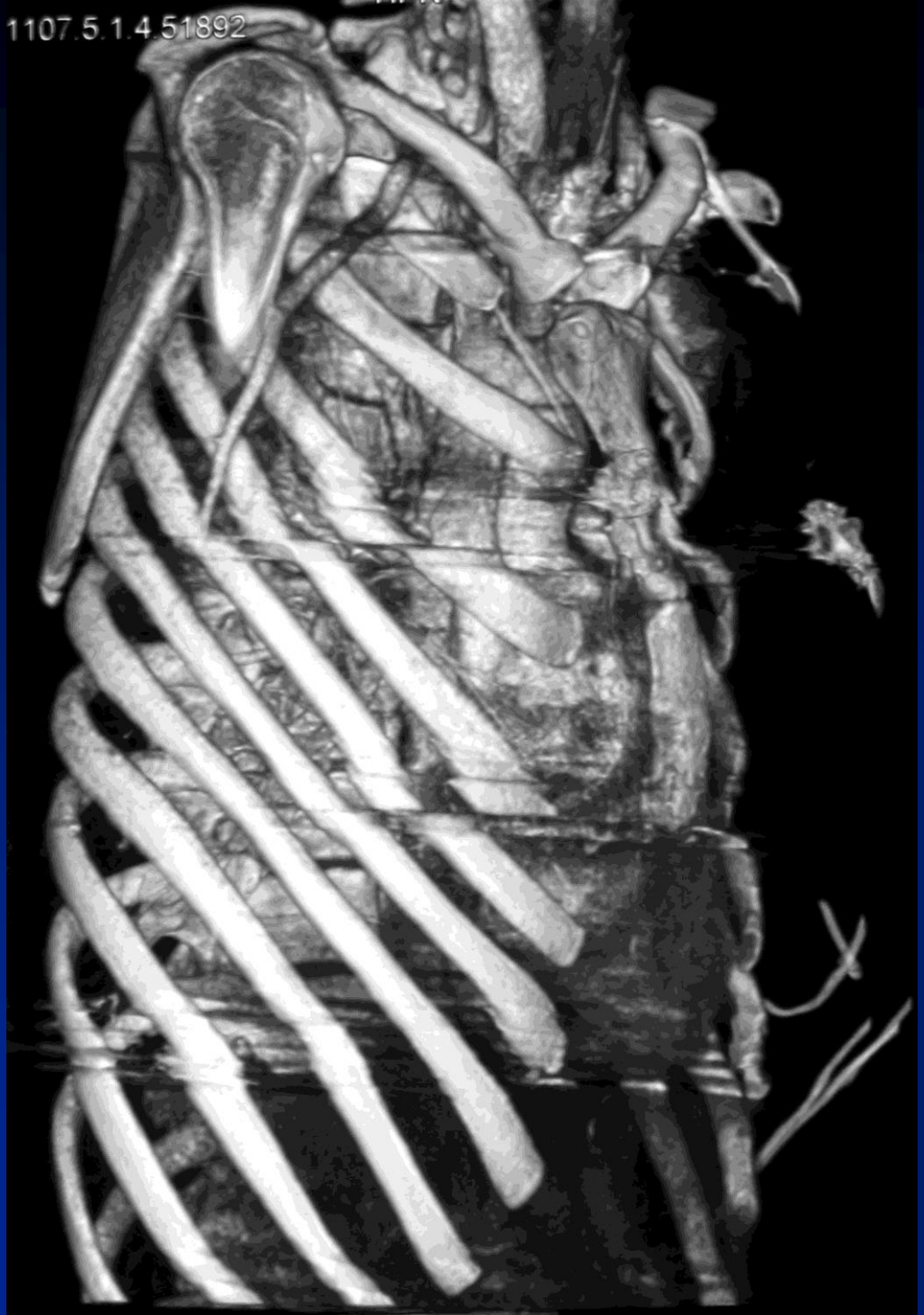
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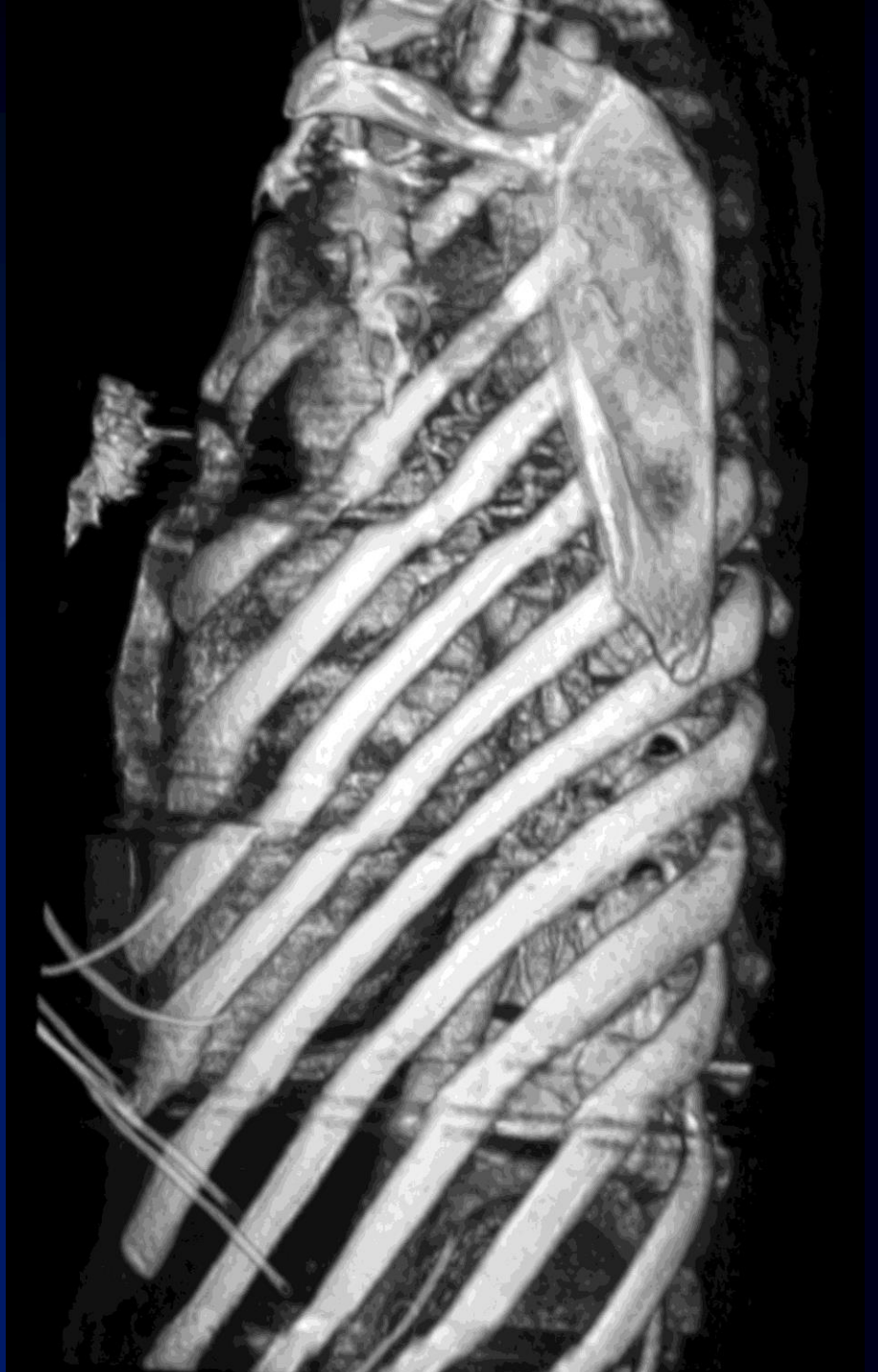
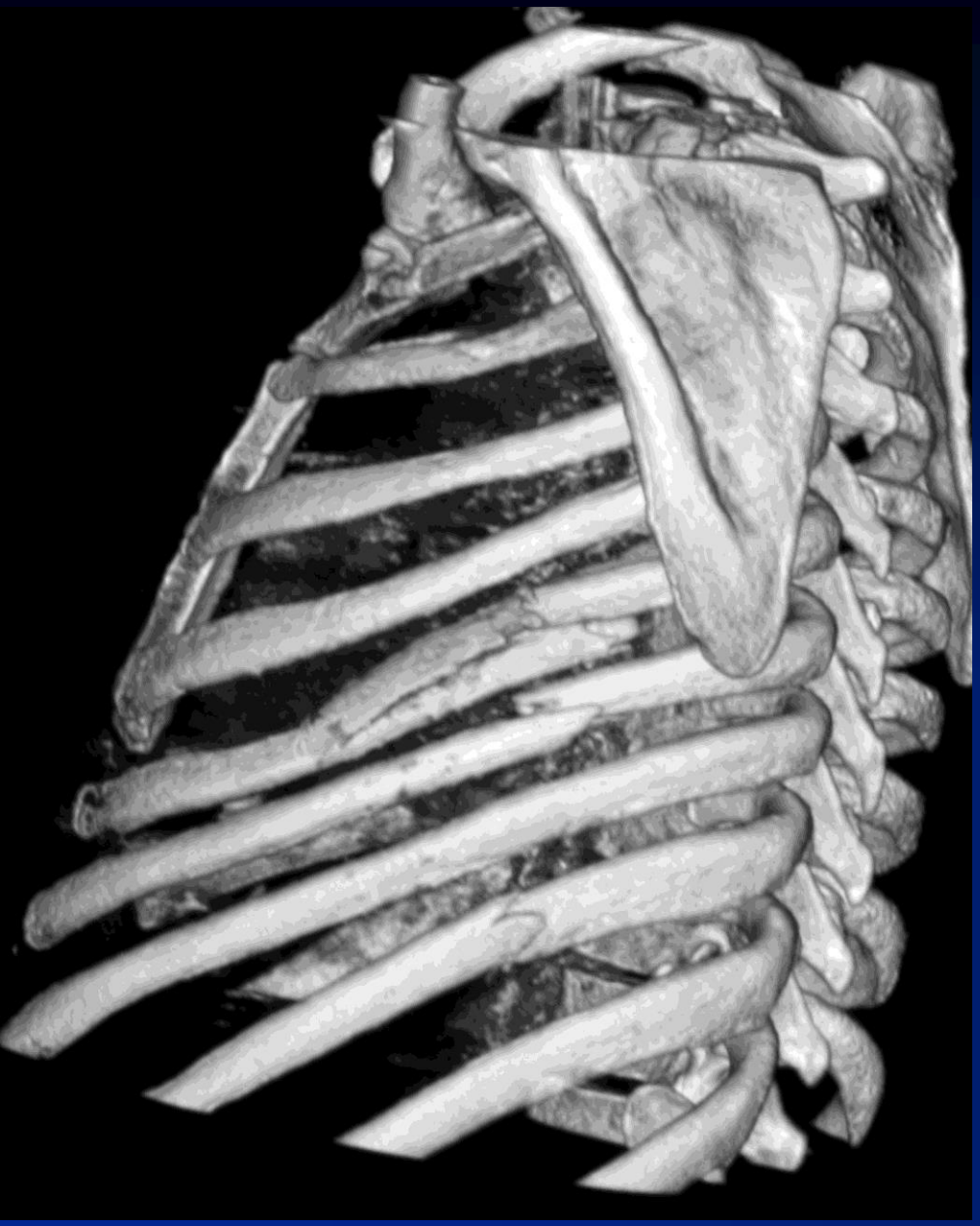


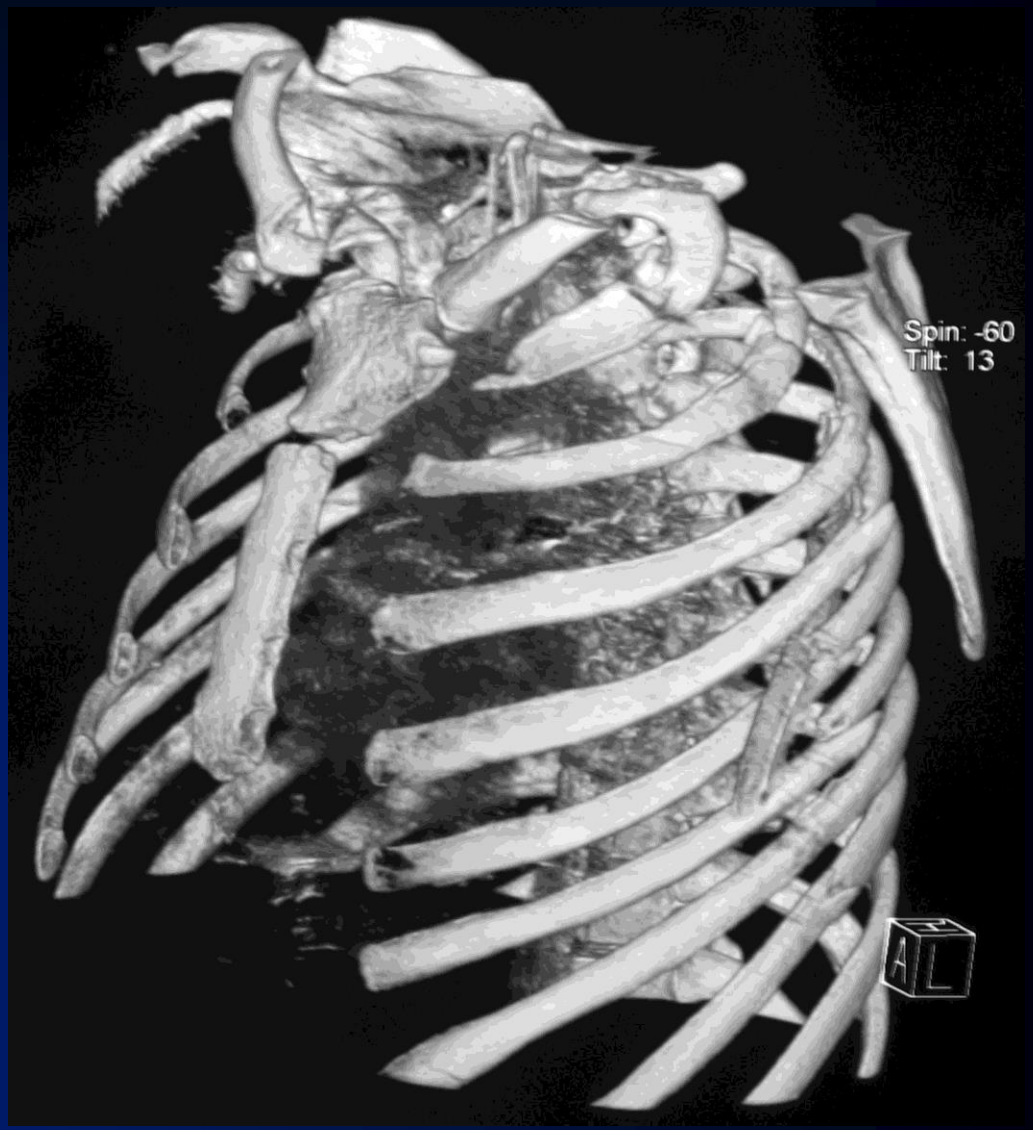
Osseous Injuries

Rib fractures

Flail chest

- >5 adjacent ribs # or >3 segmental ribs #
- Paradoxical move with respiration
- Respiratory failure
- Pendelluft
- At expiration, the flail hemithorax inhales
- Rebreathing of the same air
- Mechanical ventilation

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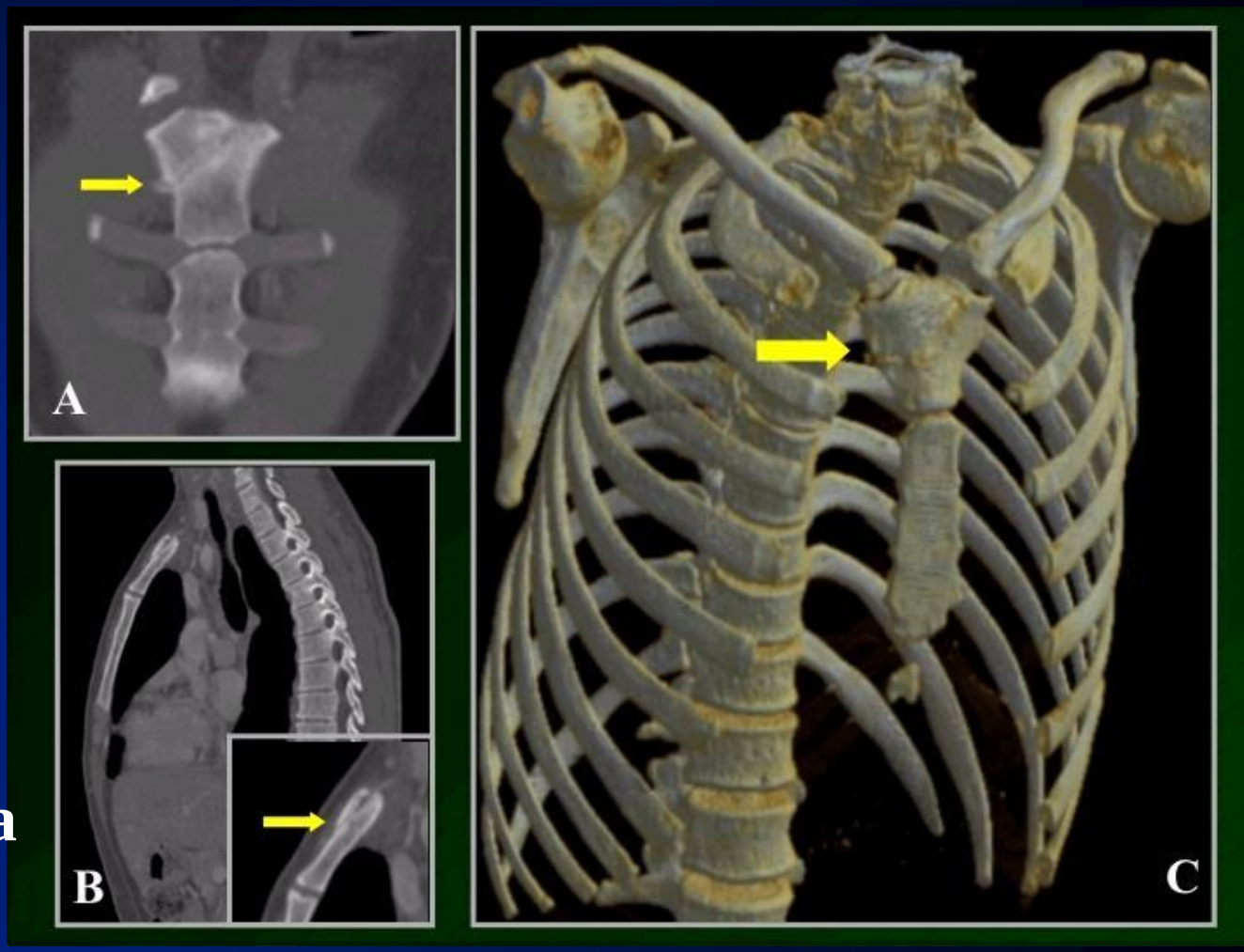
Osseous injuries

Rib fractures

- # or the first 3 ribs ⟶ severe trauma
- Airway, spinal, vascular and brachial plexus injuries
- # of the lower 3 ribs ⟶ abdominal trauma

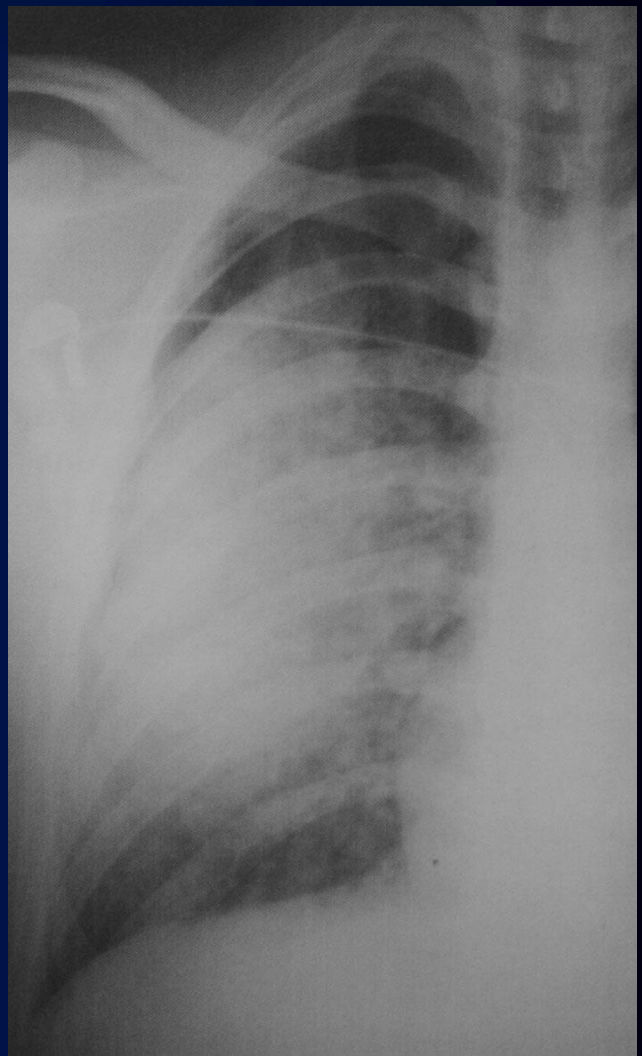
Osseous injuries
Sternal fractures

- Important as usually associated with mediastinal injuries
- Usually transverse
- Near the manubrium
- Lateral X-ray
- CT: sagittal or coronal reconstruction
- Retrosternal hematoma



Lung Injuries
Contusions

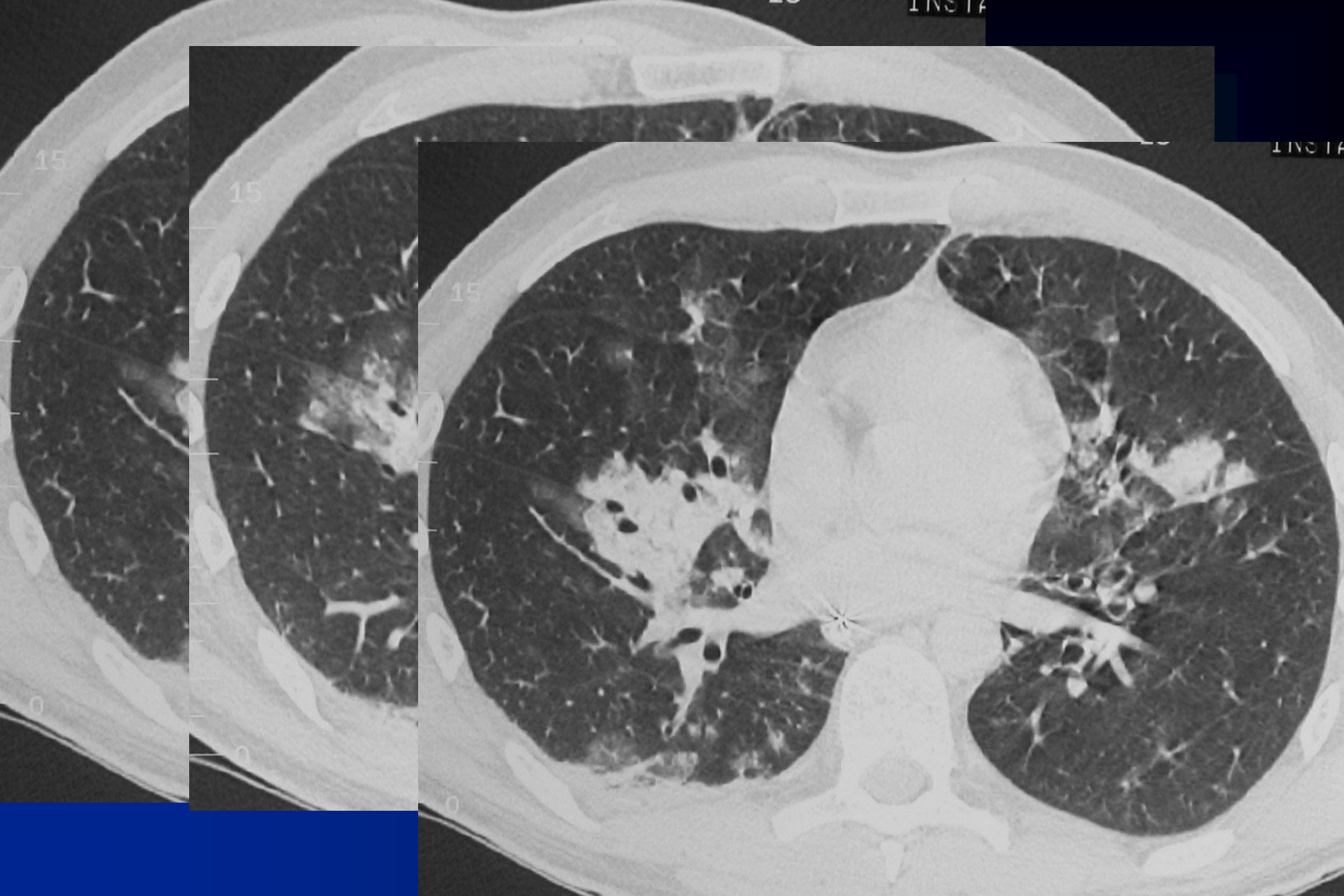
- Most common parenchymal injuries : 50 % ? (17-70%)
- Local compressive and recoil forces
- Appear rapidly and max in < 24 H
- Close to ribs, spine, heart or liver
- Various Rx presentation (CT)
- V/P mismatch, compliance ↘
- Require mechanical ventilation when > 1/3
- DD aspiration, edema, atelectasis
- Complete resolve within 1 to 2 weeks

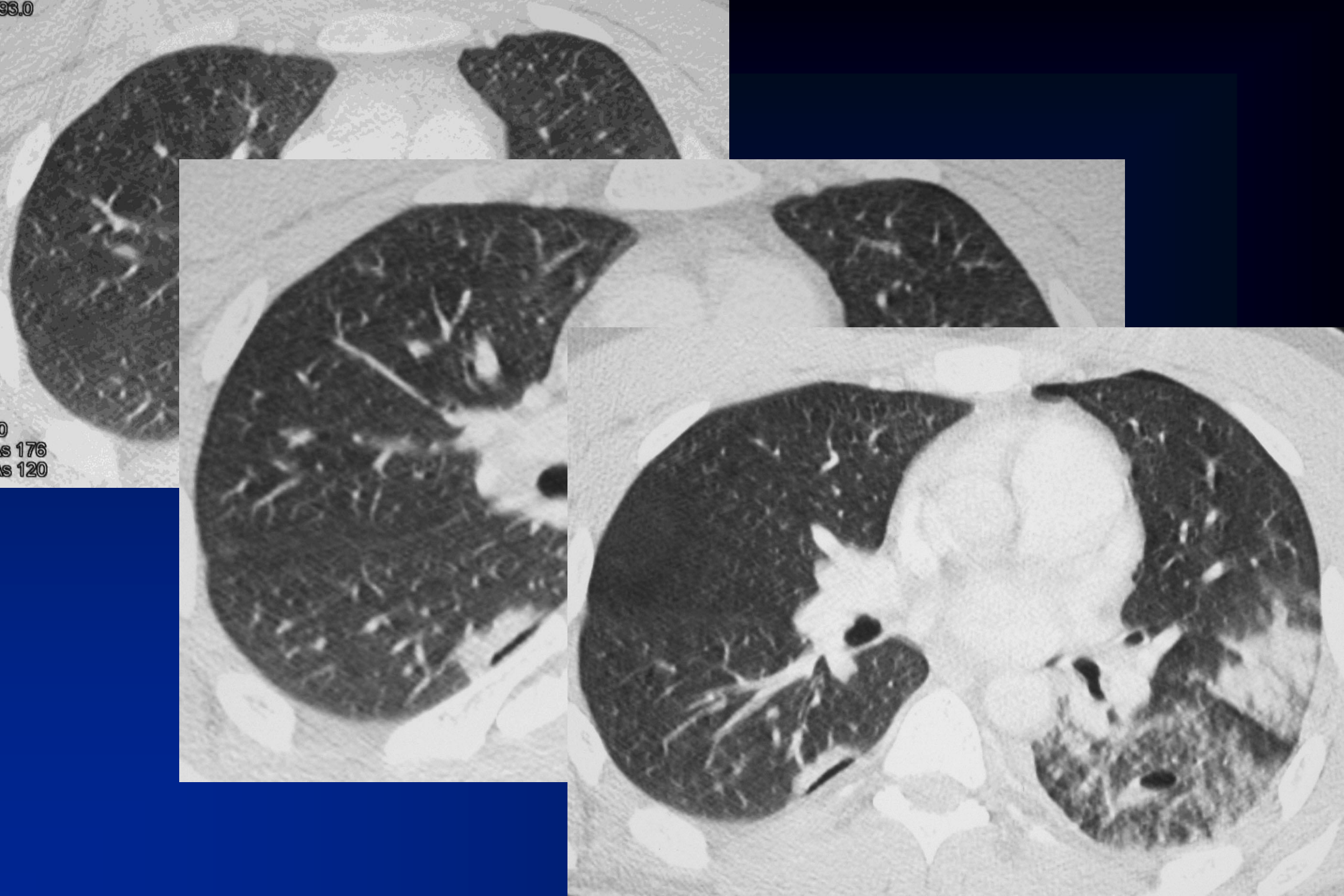


Lung injuries
Lacerations

- Shearing forces
- Intially linear, then rapidly ovoid (elastic recoil)
- May be obscured by surrounding contusions or subcutaneous emphysema
- May fill with blood ⟶ hematoma

  air ⟶ pneumatocele
- Resolve over weeks or months

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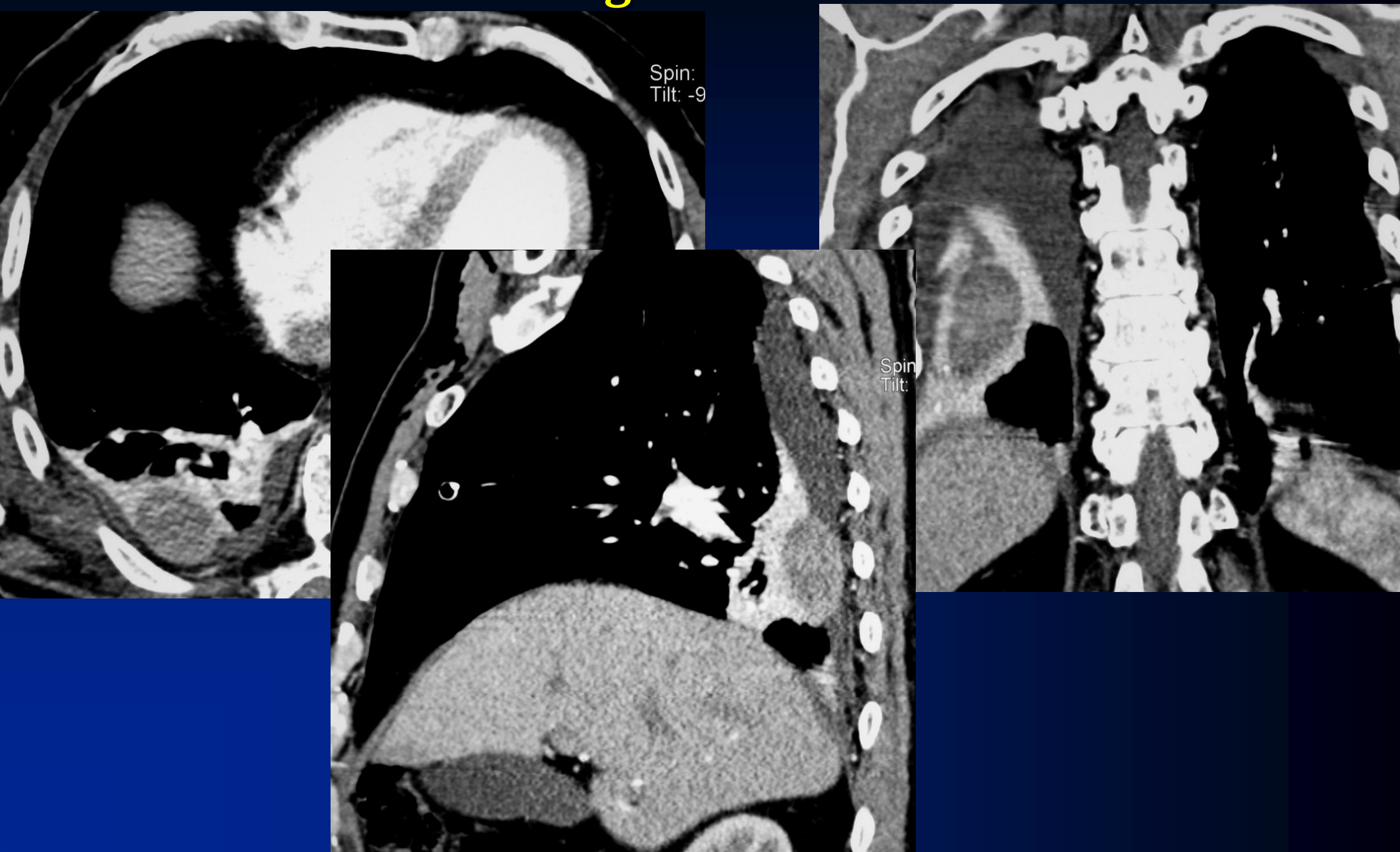
Lung hematoma



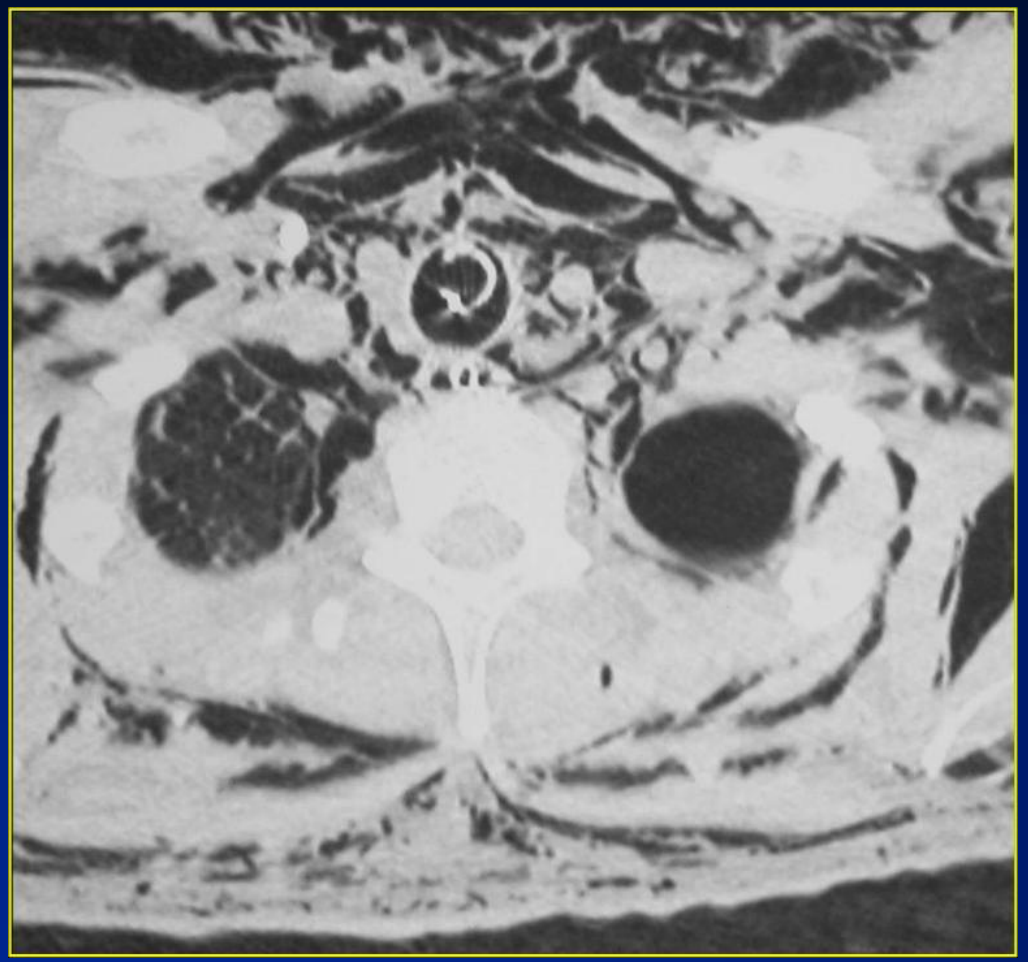
Pneumomediastinum

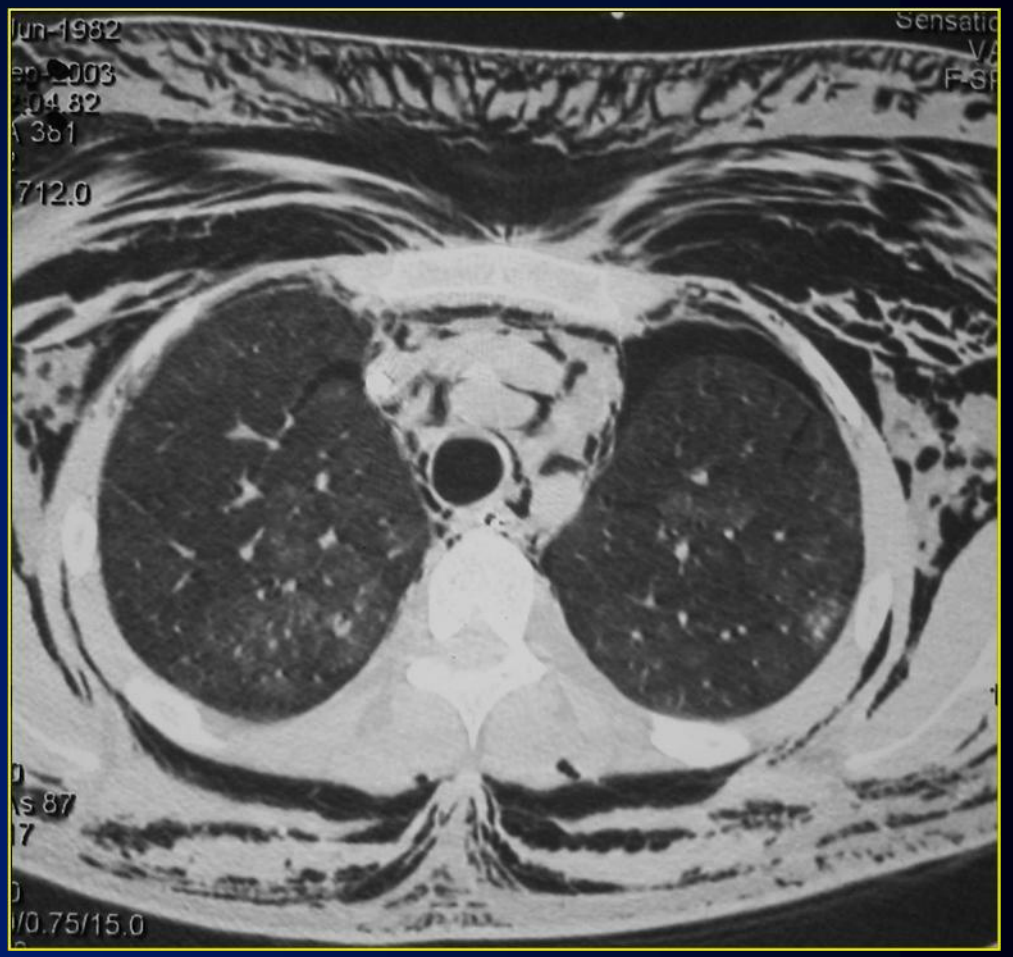
>10 % of severe blunt chest trauma

- **<2 % results from blunt tracheobronchial lesions**
- **Rarely originates from esophageal injuries**
- **Extension of cervical or thoracic subcutaneous emphysema**
- **Extension of retropneumoperitoneum consecutive to a hollow viscus rupture**

In other cases → MACKLIN effect

Wintermark M, Schnyder P; CHEST 2001; 120:543-547

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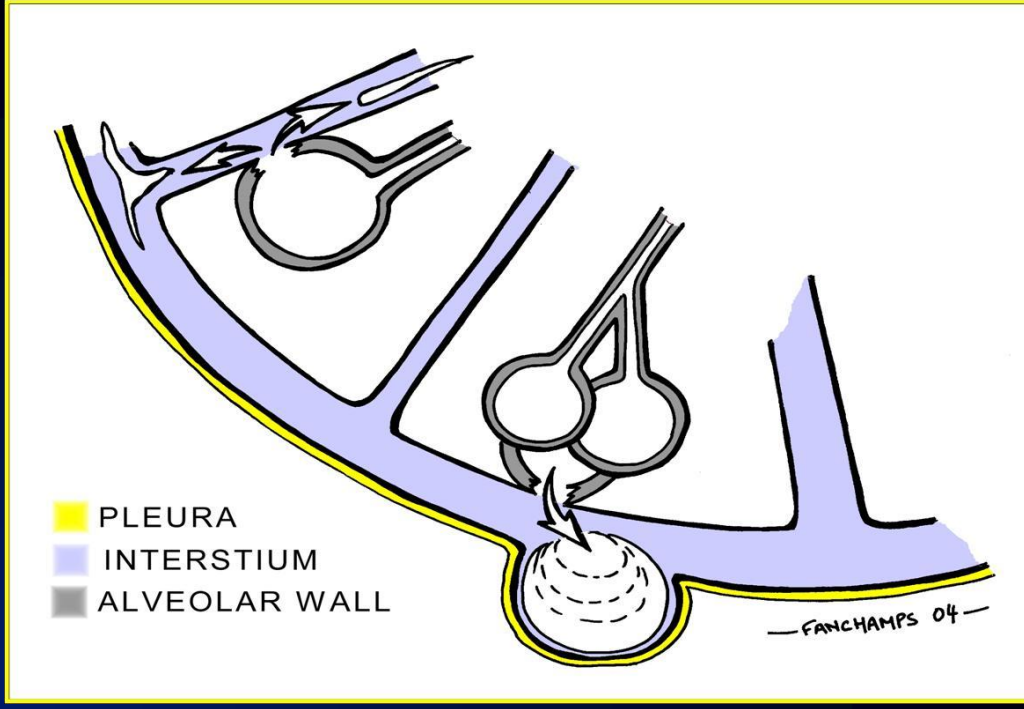
The MACKLIN effect



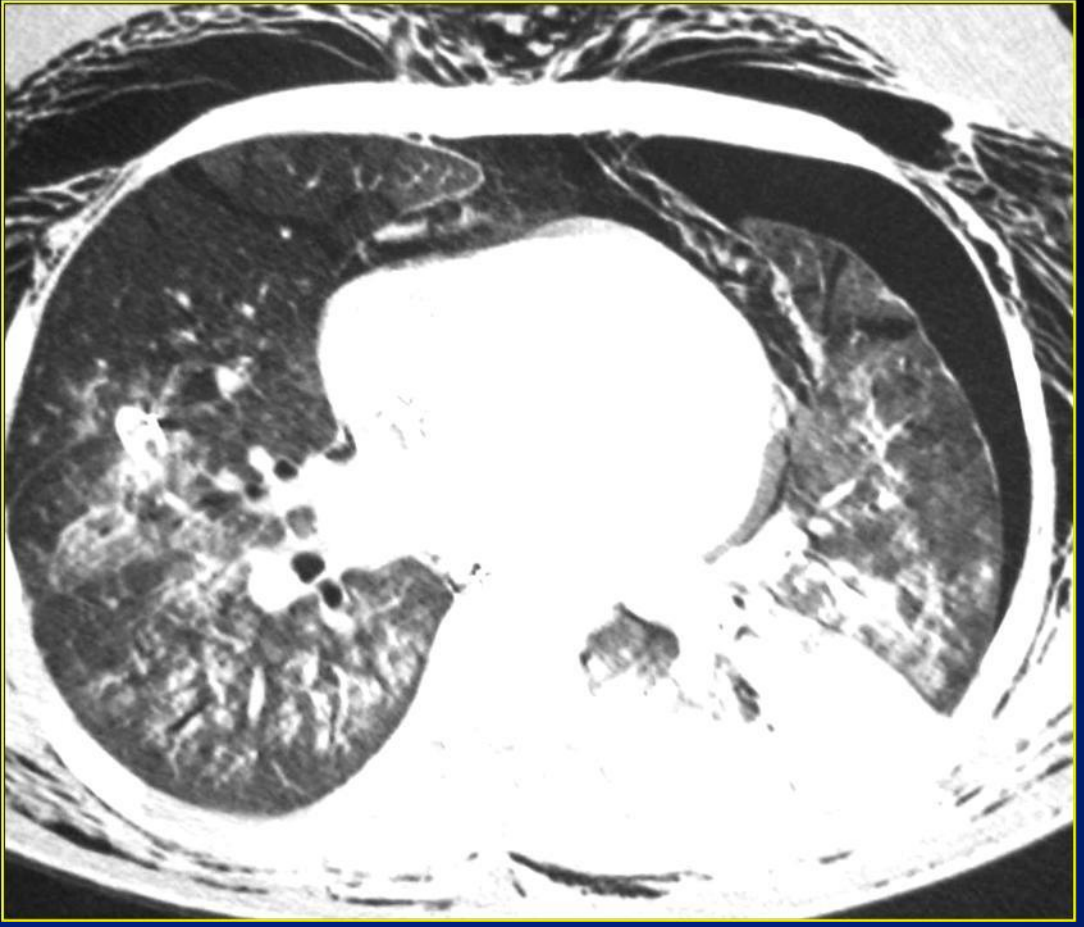
- Macklin (1939) → Overinflation of cat lungs
- High-pressure gradient between alveoli and pulmonary interstitium leads to

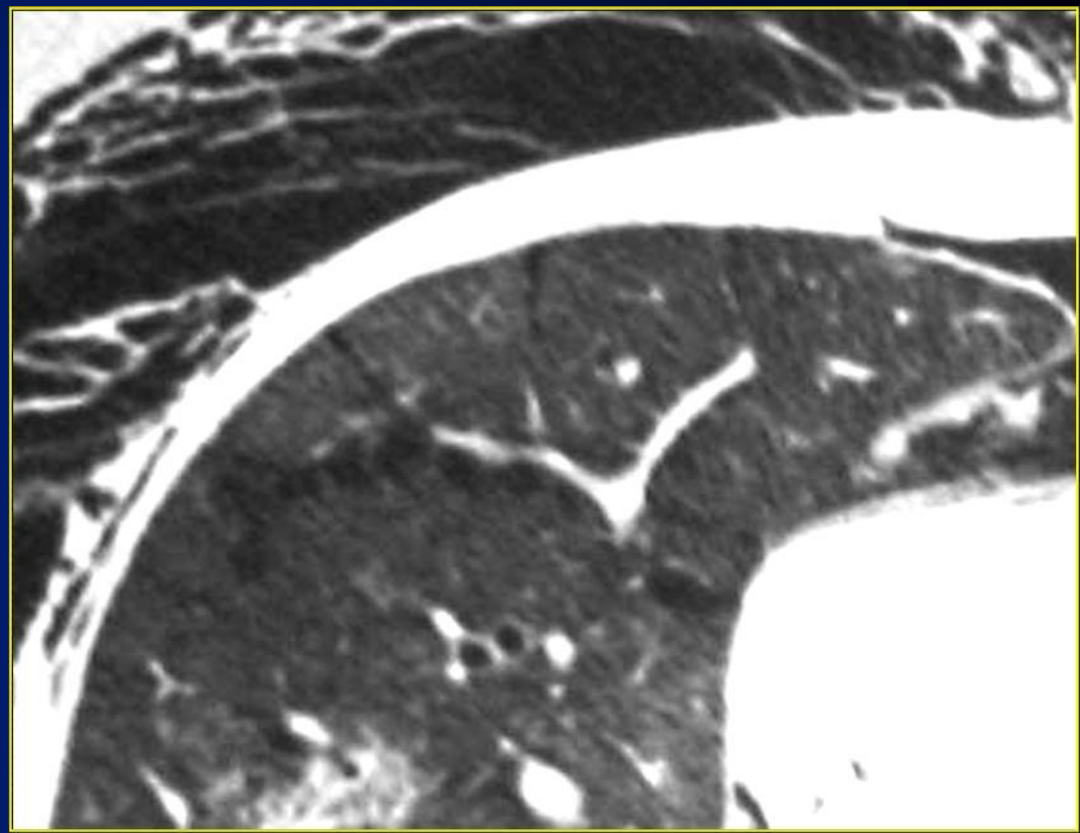
  (1) alveolar rupture with

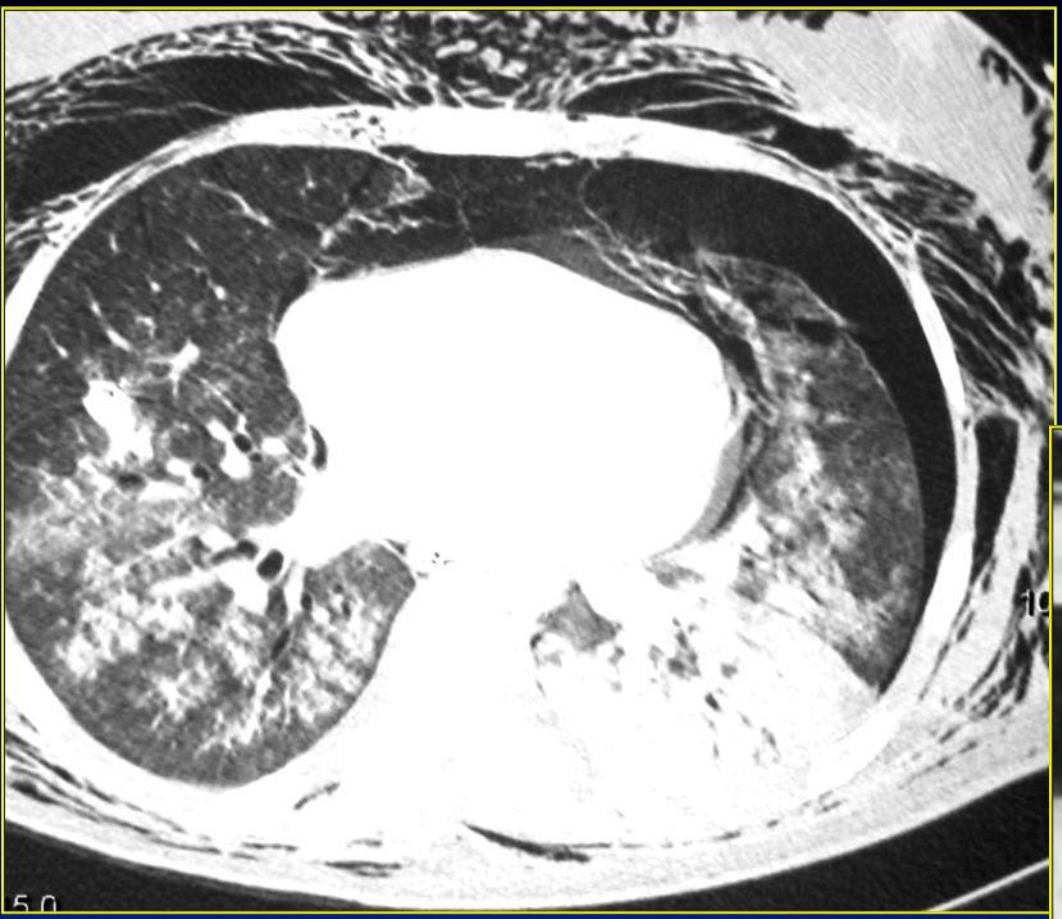
  (2) dissection and coursing of free interstitial air along the connective tissue surrounding the bronchi and pulmonary vessels

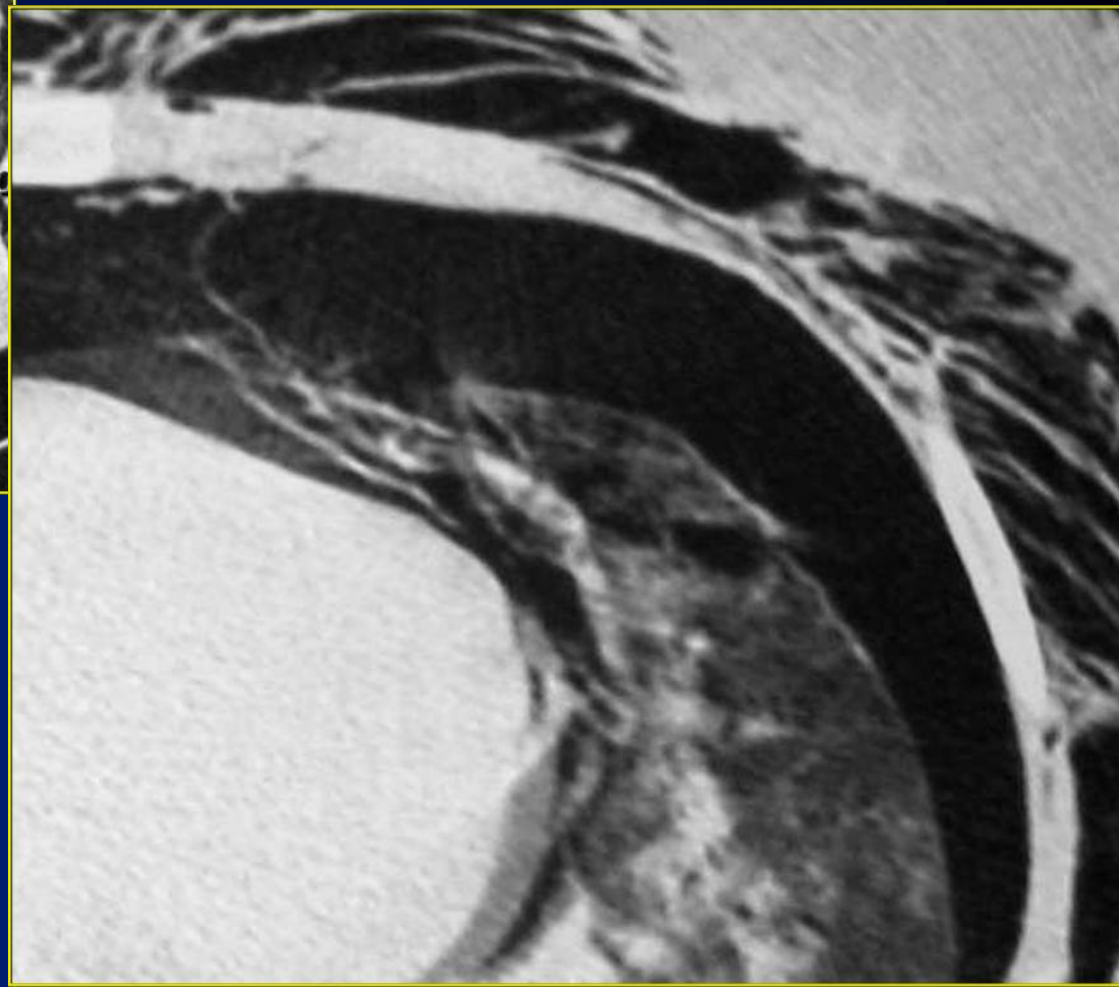
  (3) toward the mediastinum

- Continuity between mediastinal and peribronchial facial planes (Marchand 1951)









The MACKLIN effect

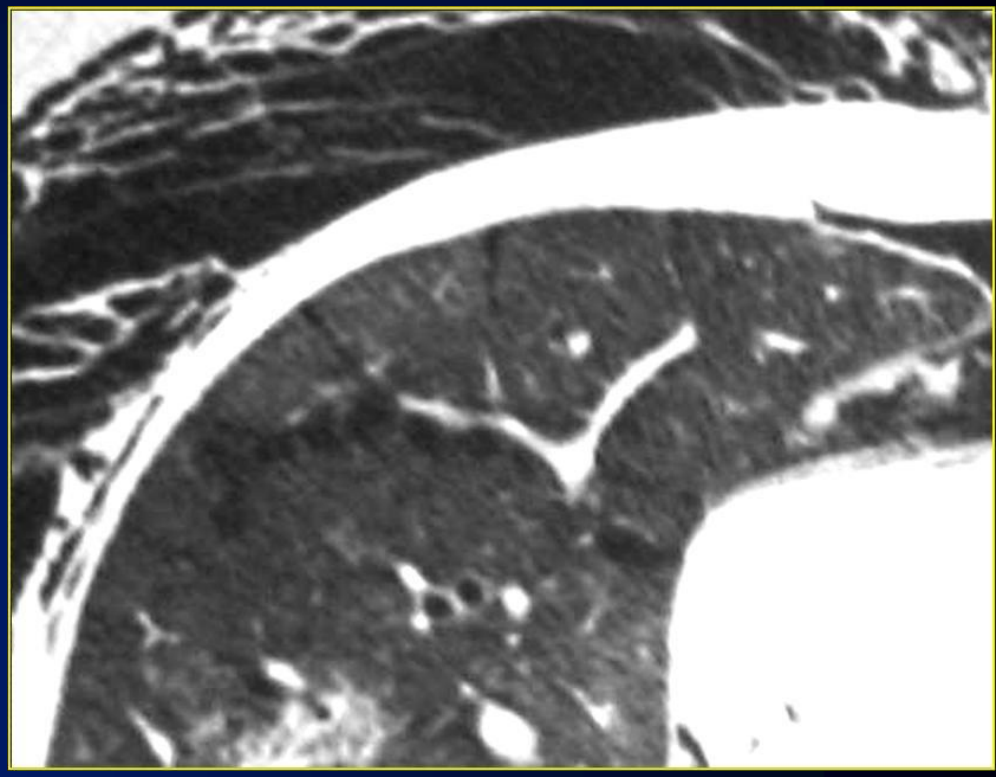
Complications of the Macklin effect + mechanical ventilation

50% after > 4 days

- → **(Tension) pneumomediastinum**
- → **(Tension) pneumothorax**
- → **(Tension) pneumopericardium**
- → **(Tension) pneumoperitoneum**
- → **Rarely gas embolism**

Pulmonary Interstitial Emphysema

Differential diagnosis between pulmonary interstitial emphysema and bronchus



- **Localisation**
- **Not limited by a wall**
- **No diameter tapering from hilum to periphery**
- **Air on both sides of the vessel**

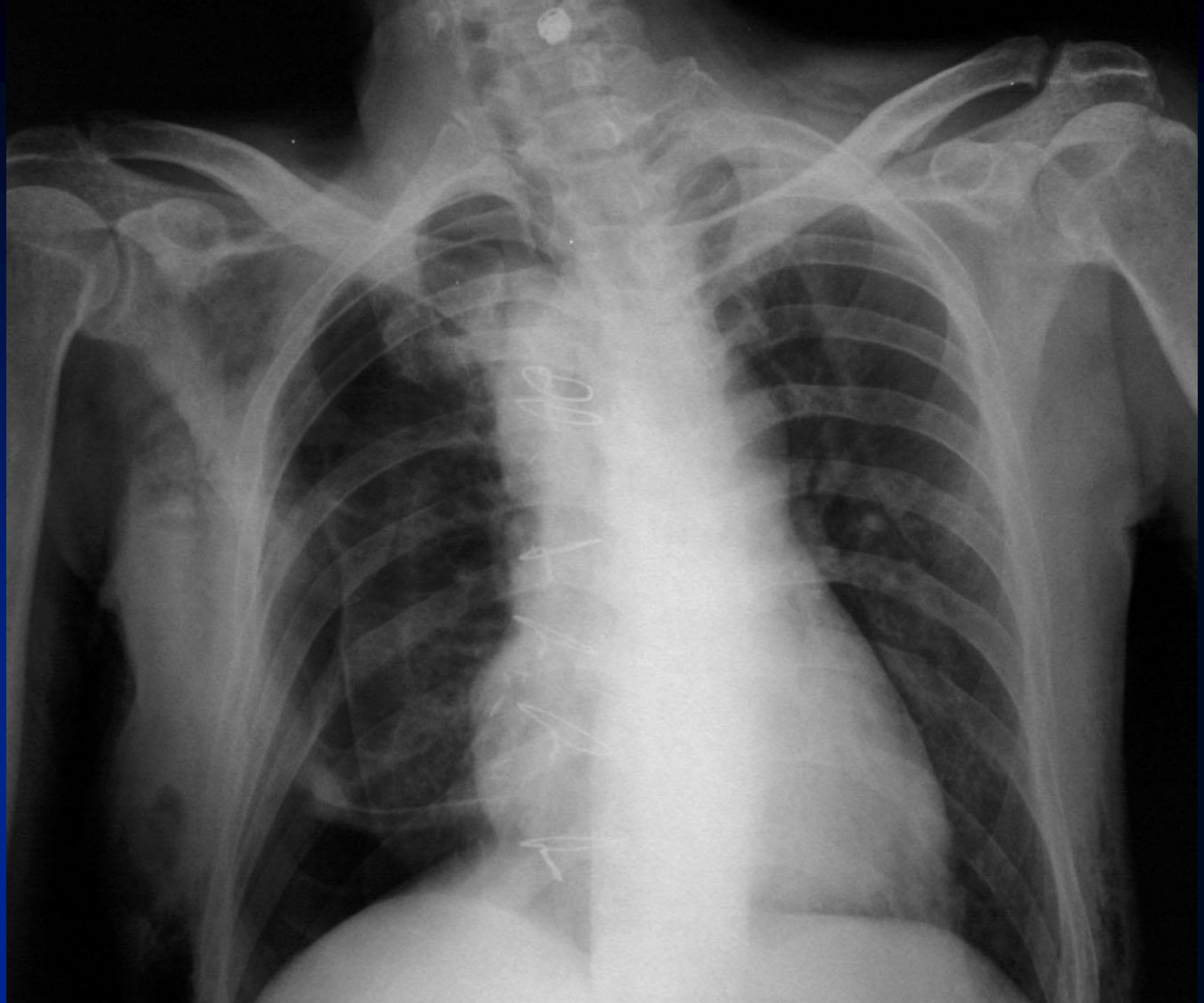
  (bronchus : external side of vx in UL and internal side in LL, ML and lingula)
- **Target sign (in perpendicular plane)**

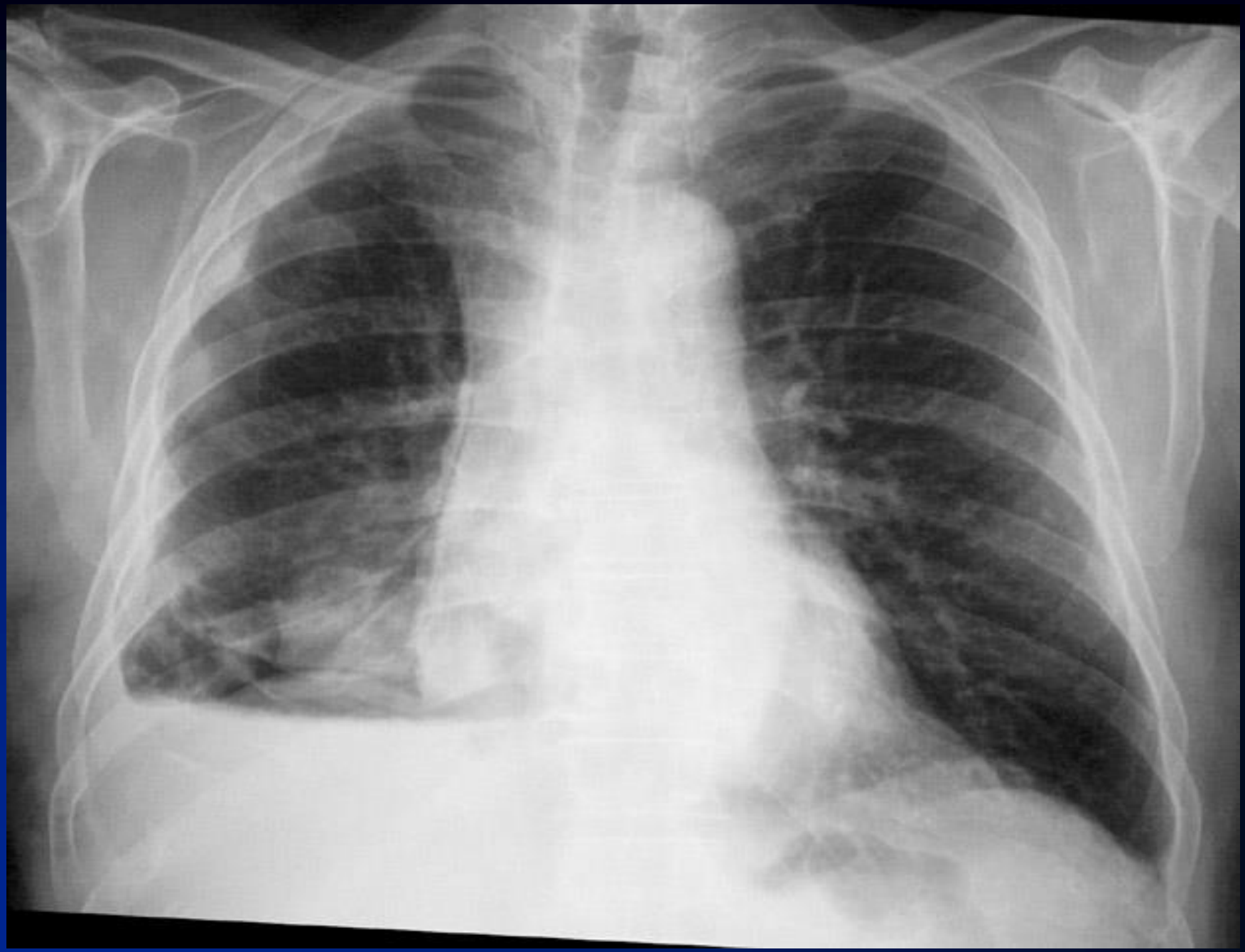
CHEST IMAGING IN ICU

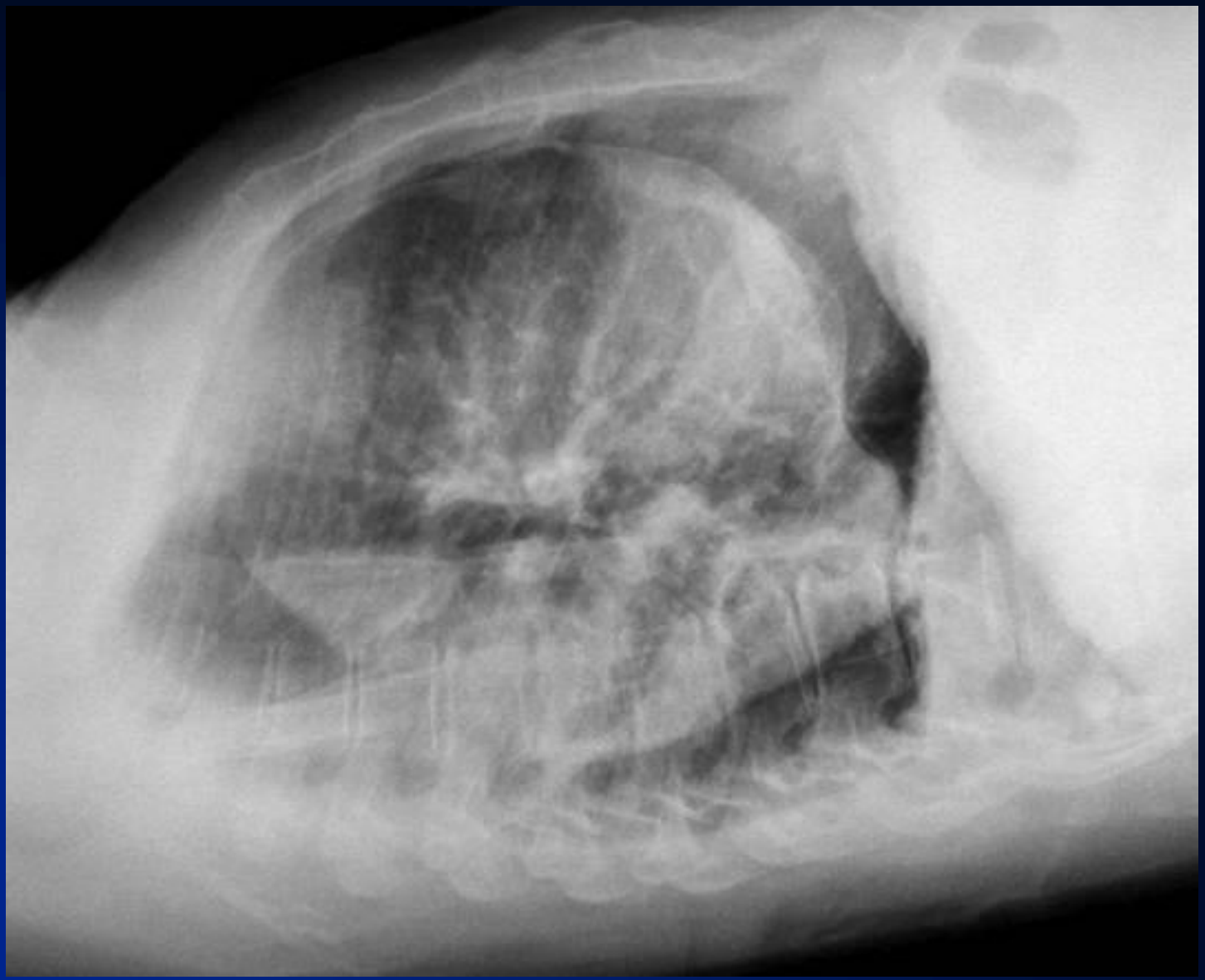
PNEUMOTHORAX

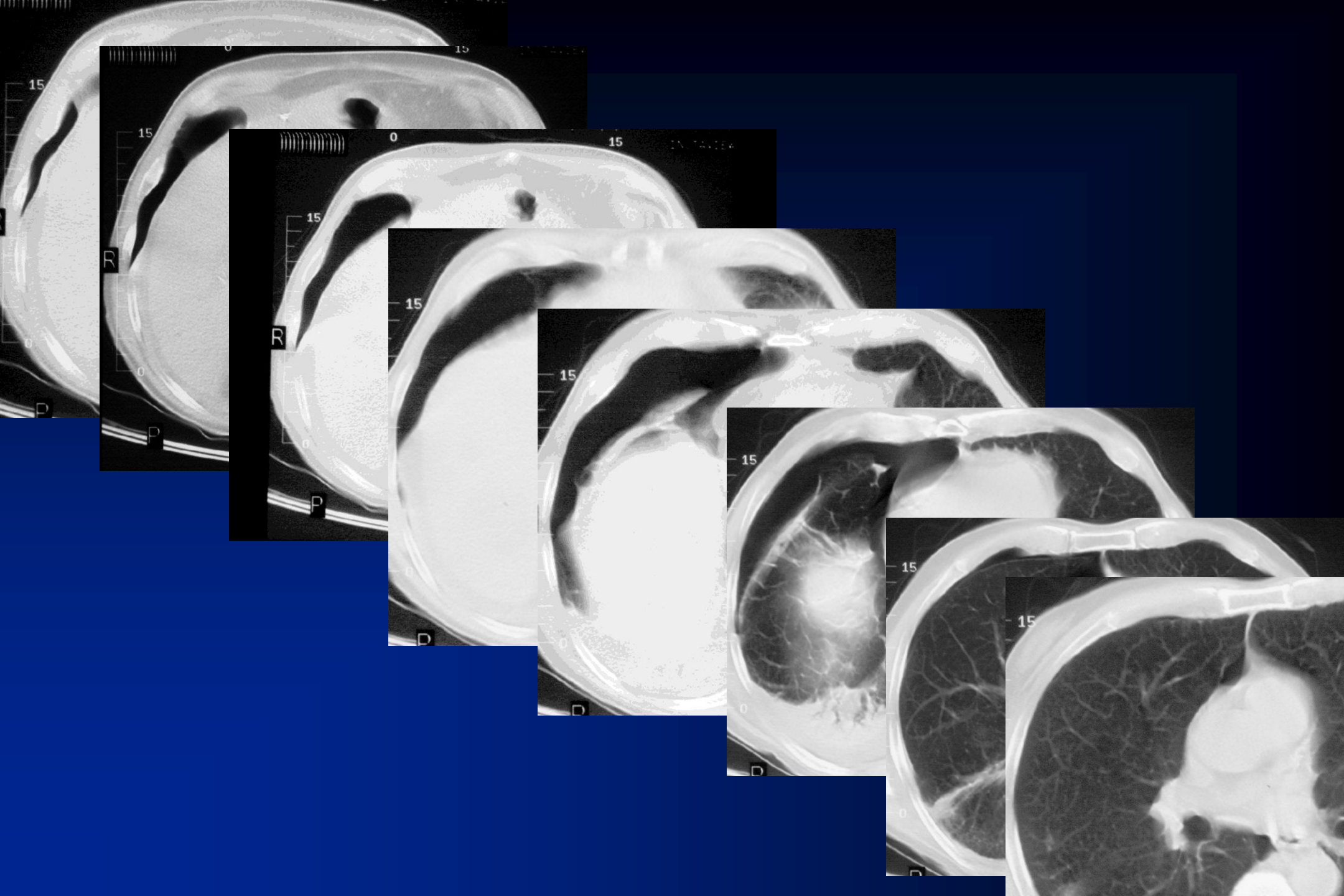
- **Position of the patient:**
  supine → anteromedial or subpulmonic recesses
  - → basal hyperlucency
  - → enhanced sharpness of adjacent structure
  - → "double diaphragm sign"
  - → "deep sulcus sign"
  - → pericardial fat tags
  - → inferior edge of collapsed lung

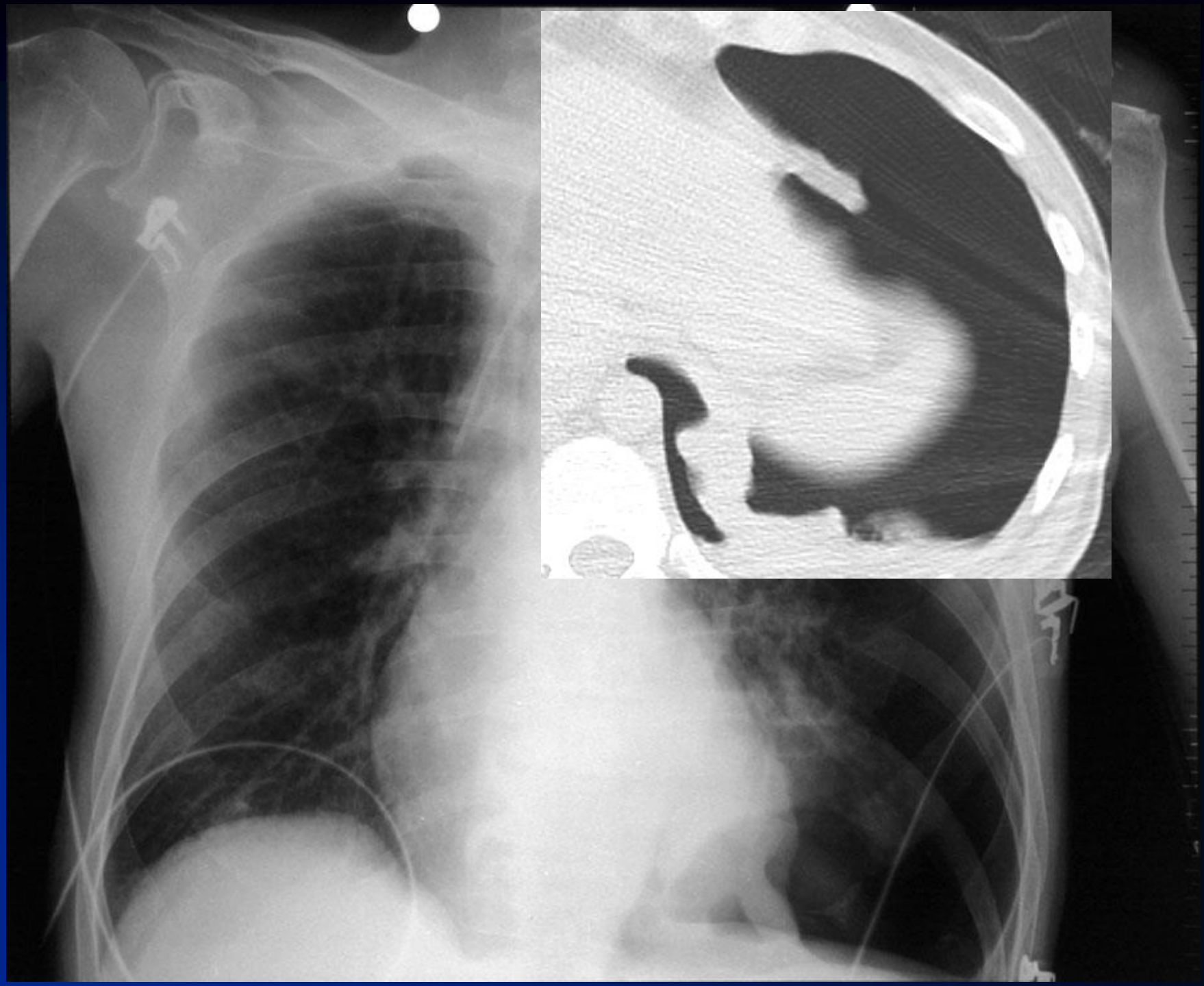
- **Underlying pleural or parenchymal disease**
  - pleural adhesions
  - collapsed or consolidated lung
  - alteration of chest wall recoil

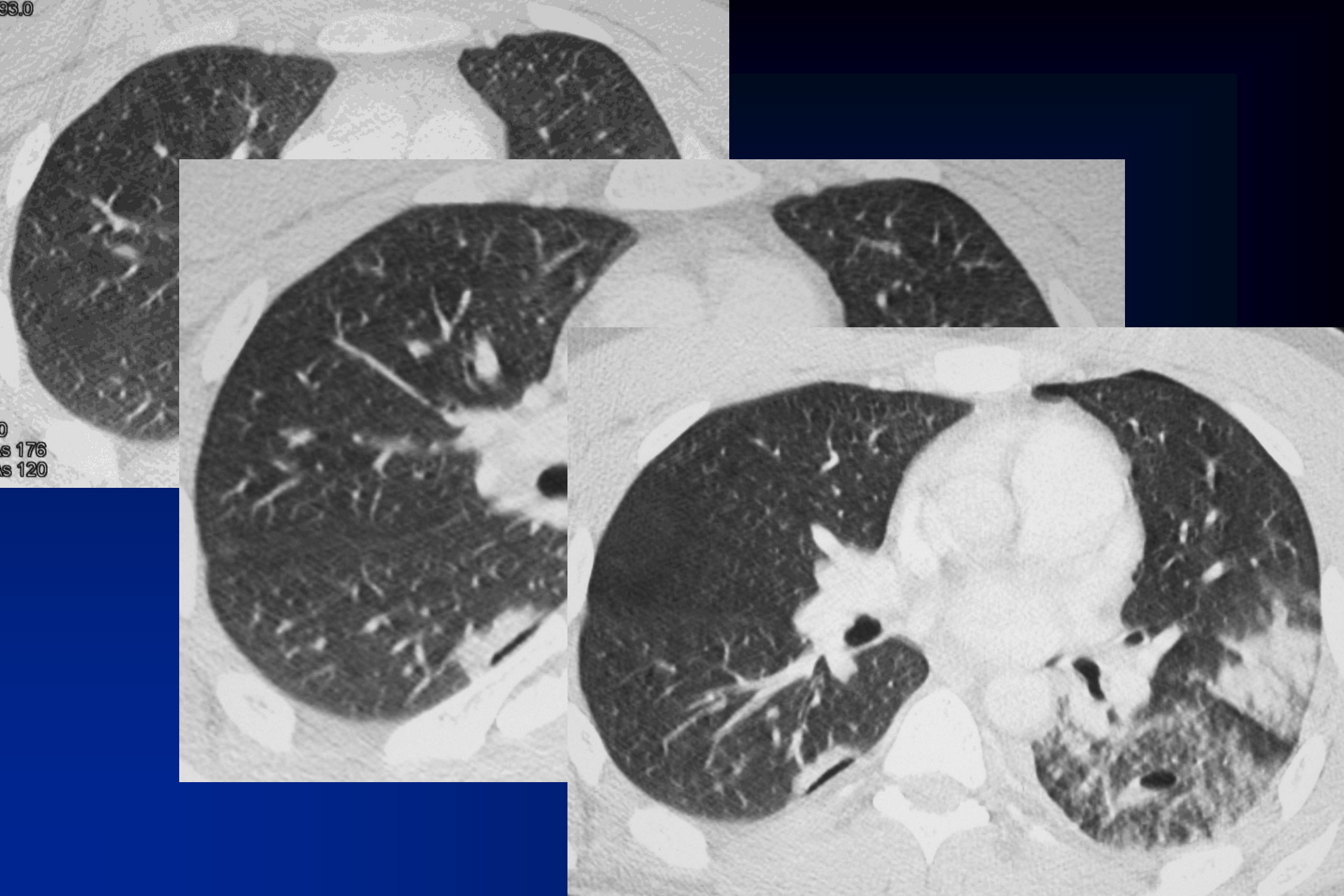








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CHEST IMAGING IN ICU

PNEUMOTHORAX

TENSION PNEUMOTHORAX

- Striking collapse of the lung
- Contralateral mediastinal shift
- Straightened heart border
- Compressed SVC and IVC
- Widened intercostal spaces
- Flattening or inversion of hemidiaphragm

Pleural injuries
Fluid

- Blood or chyle
- Typically low-pressure and self-limited
- May appear for several hours after trauma

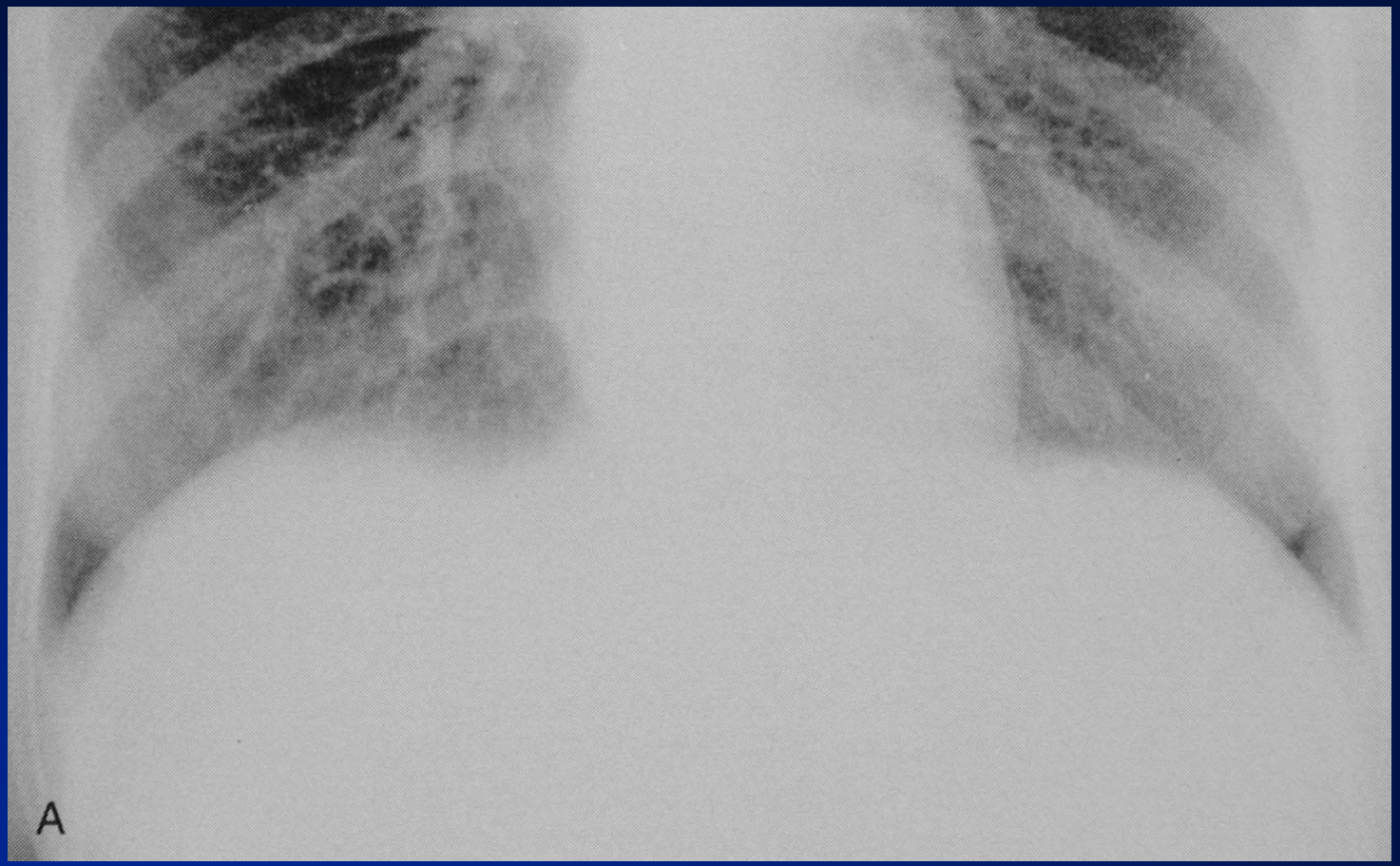
Pleural injuries
Effusions

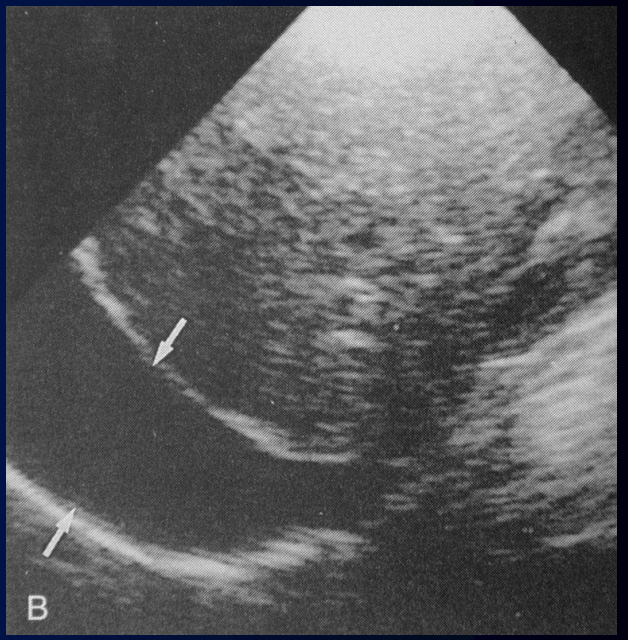
- Free fluid → most dependent areas

→ supine position

- increased density of the hemithorax
- preserved visibility of vessel margins
- loss of limits of diaphragm
- apical cap
- meniscus sign
- fluid in fissures

Pleural injuries
Effusions



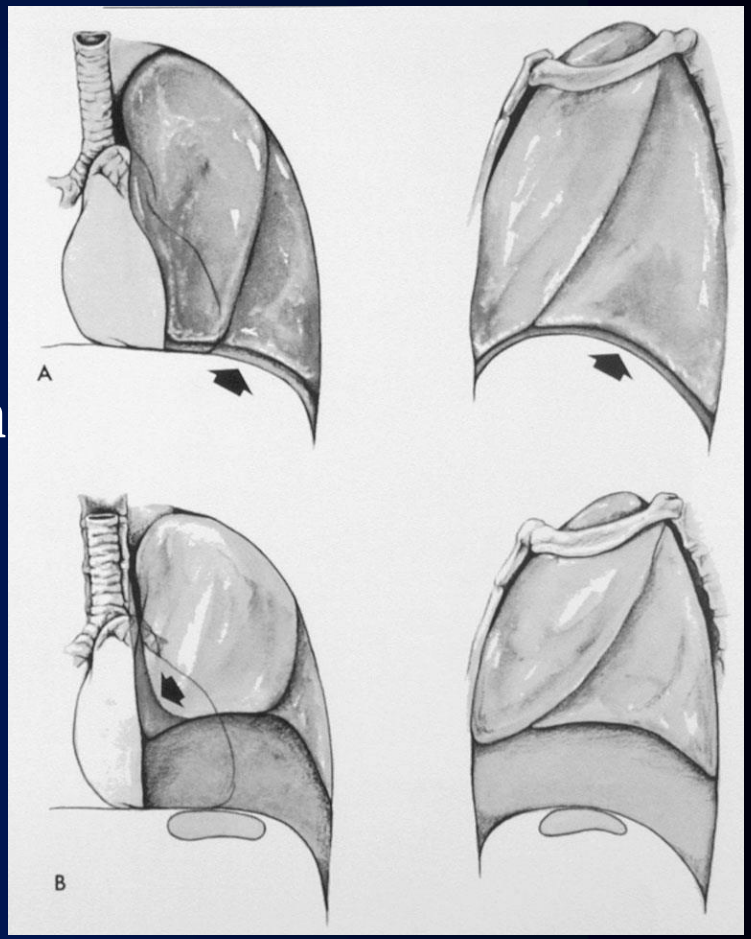


Pleural injuries
Effusions

Semi-upright or upright position

→ **subpulmonic effusion**

- apparent elevation of the hemidiaphragm
- lateral displacement of the hemidiaphragm
- visibility of lower lobe vascularity ↘
- density of liver or spleen ↗



Epanchement sous-pulmonaire

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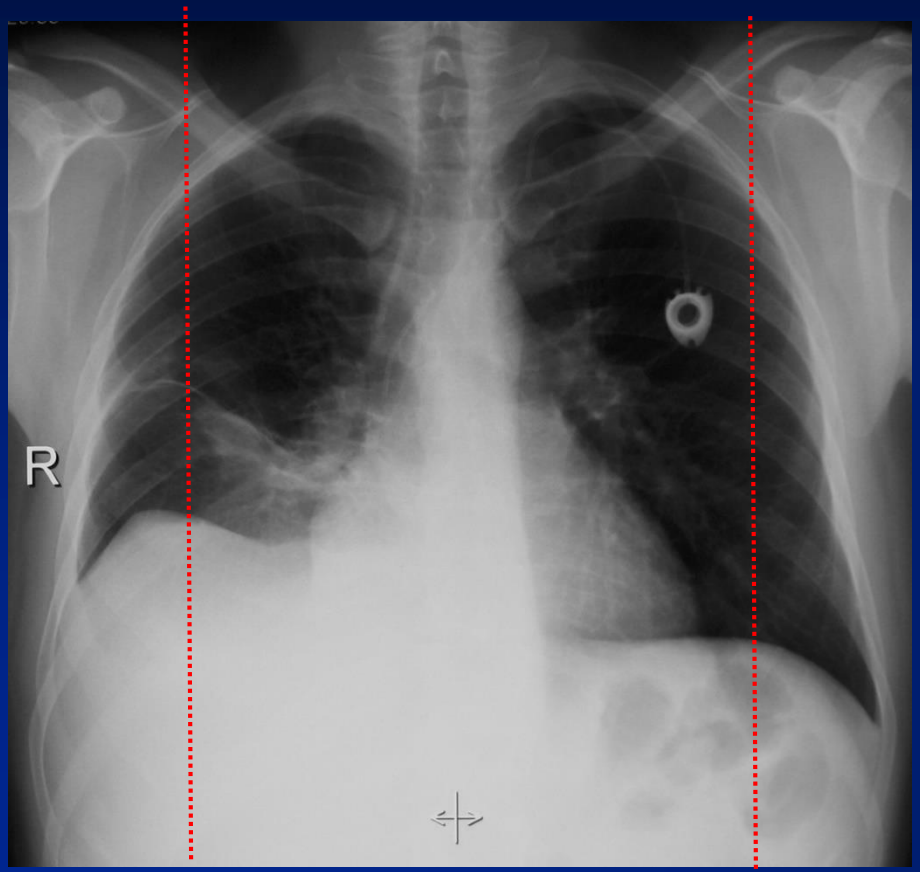
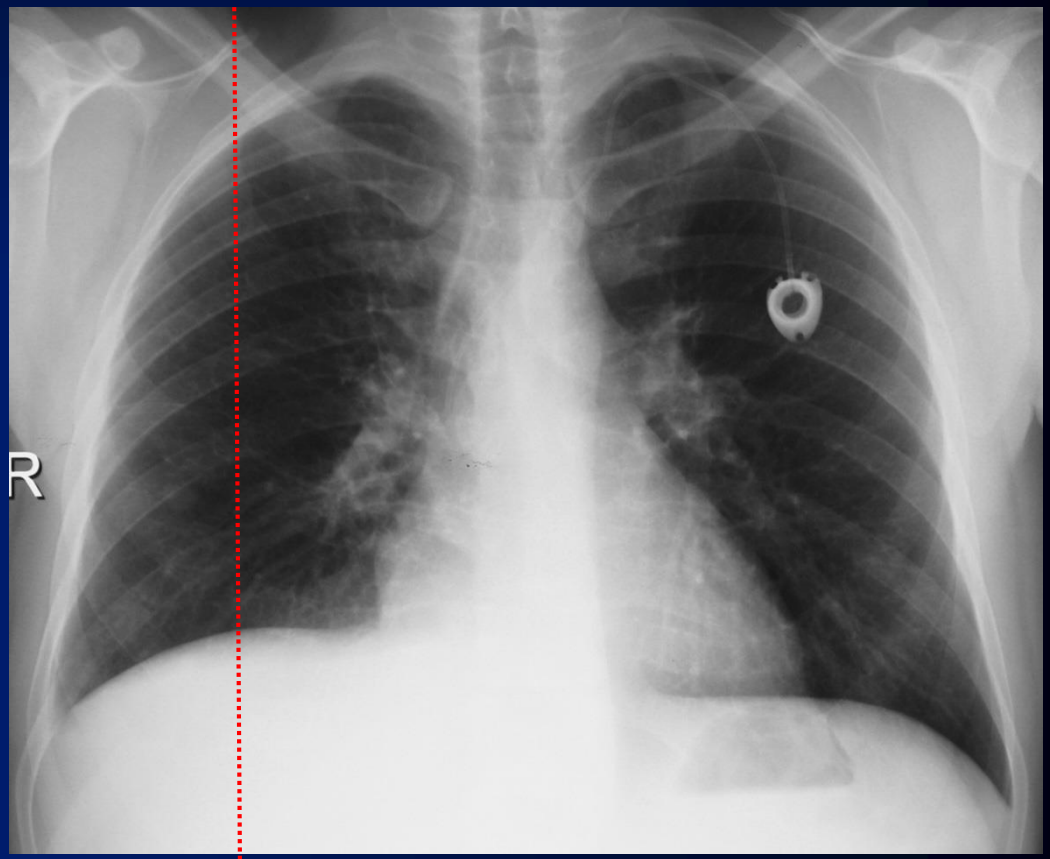


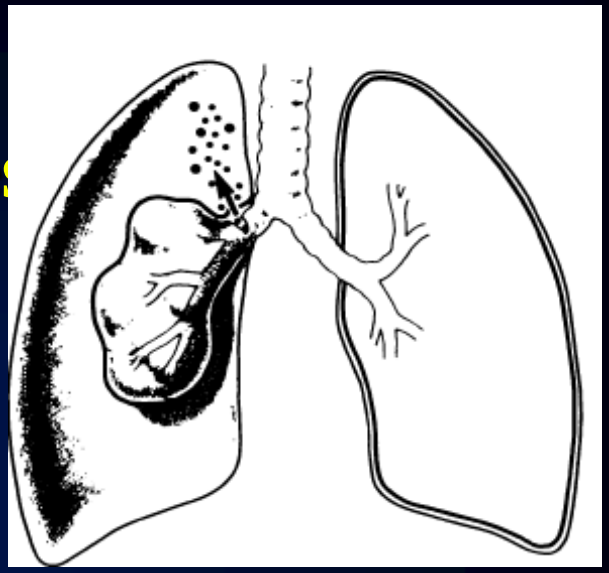


Après thoracocentèse

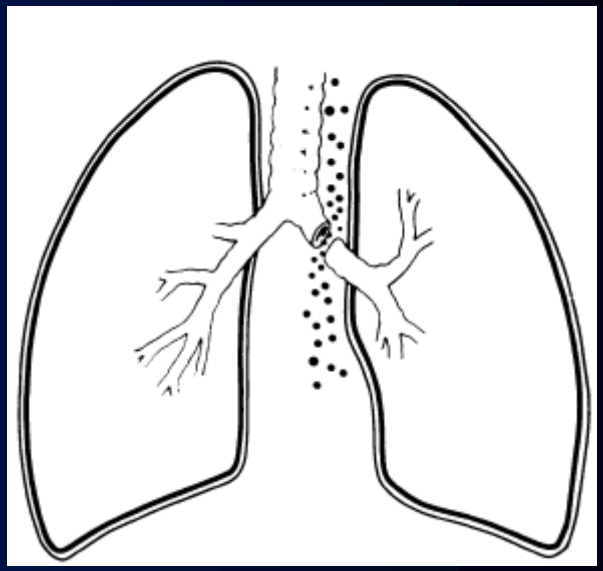
Tracheobronchial injuries

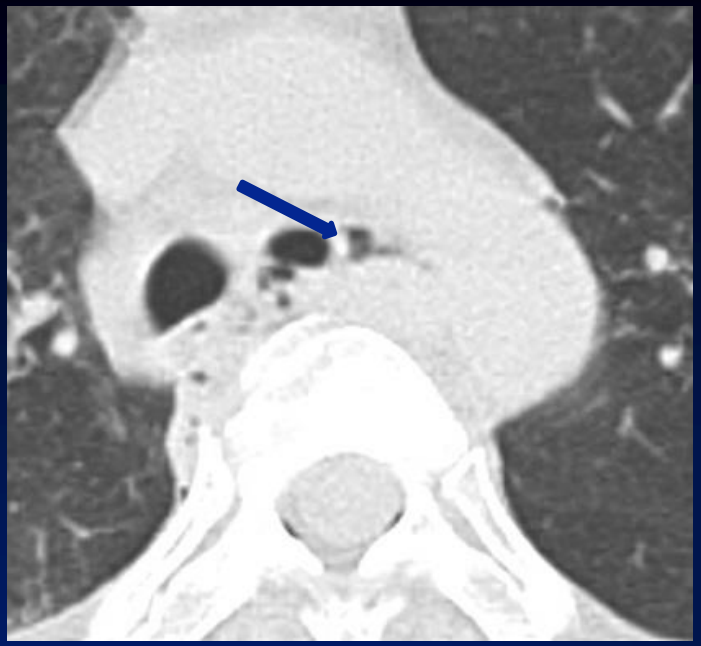
- 1 % of major chest trauma
- 30 % mortality
- Compression, shearing forces, ↗ intraluminal pressure
- 80 % within 2.5 cm from carena (RMB)
- Often associated with # (first three ribs)
- Partial or complete
- Clinical signs variable (mechanical ventilation!)
- Delayed diagnosis (increasing air in mediastinum, pleura, subcutaneous, stenosis, trapping, atelectasis, pneumonia)
- Bronchoscopy

Tracheobronchial injuries

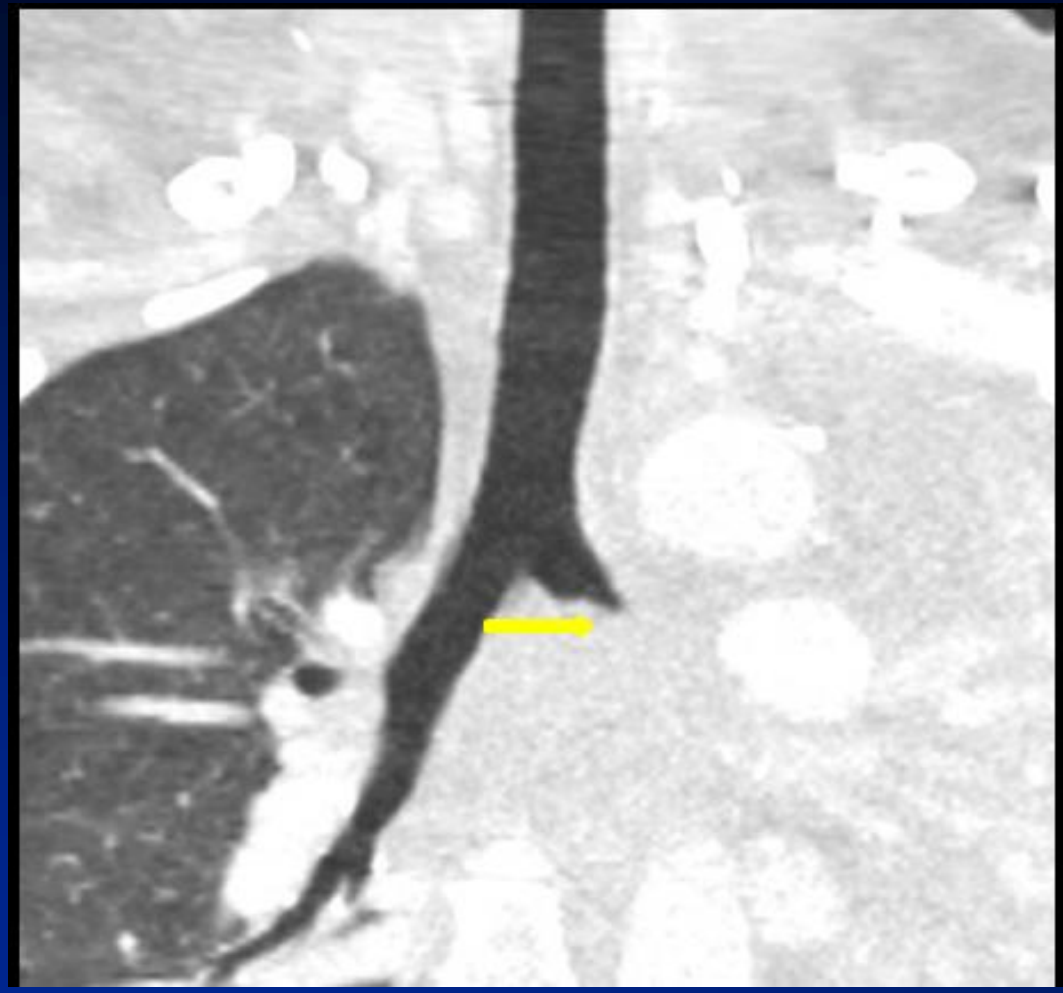


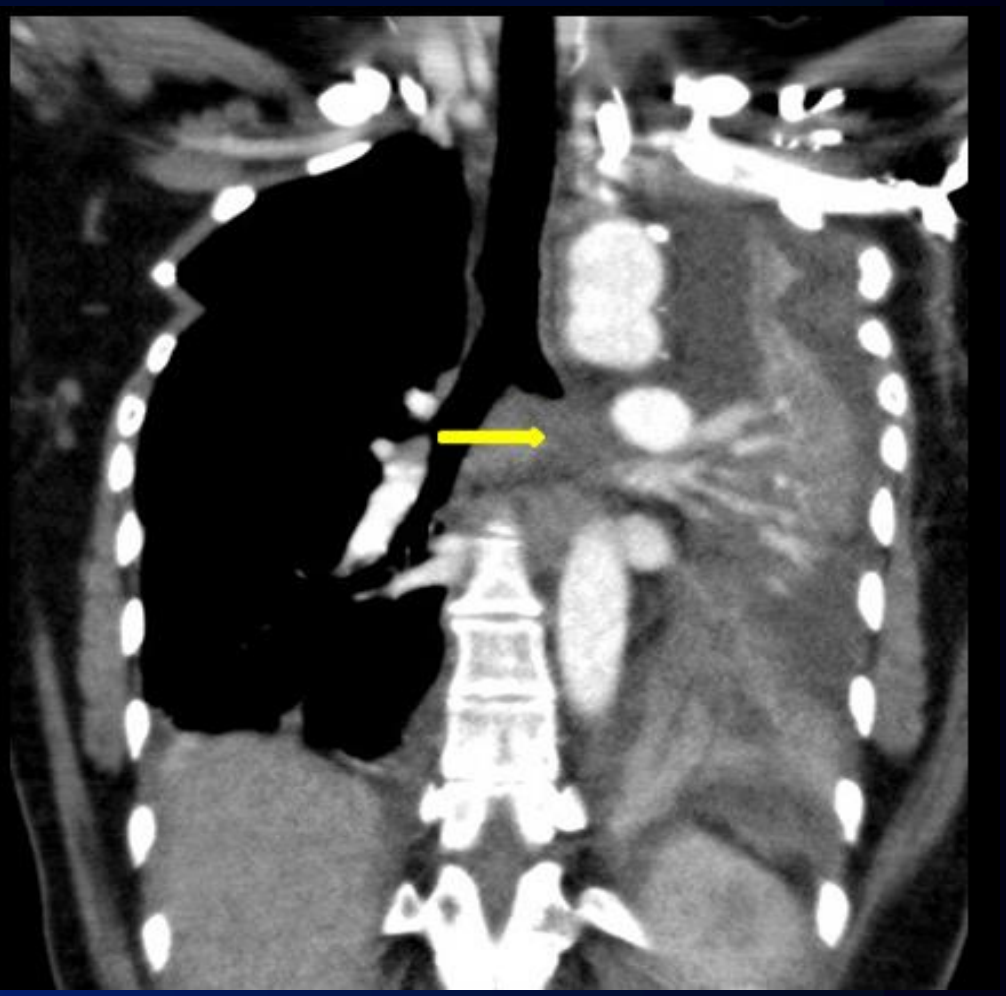
- Pneumomediastinum (pending on location)
- Pneumothorax (pending on location)
- « P » sign (pneumothorax/mediastinum, persistant, progressive)
- « Fallen lung » sign
- Interstitial air within airway wall
- Ectopic location of ET
- Overdistention of ET cuff balloon

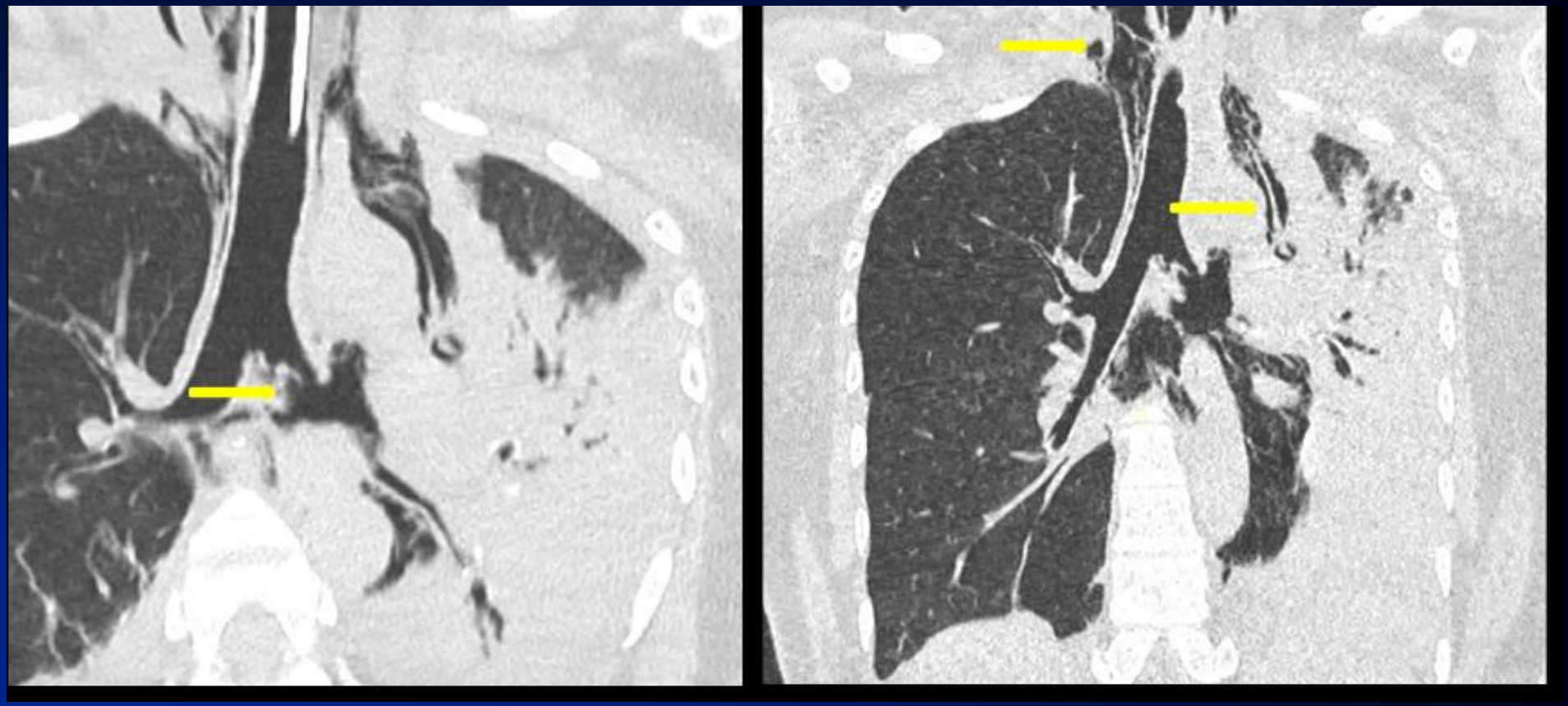






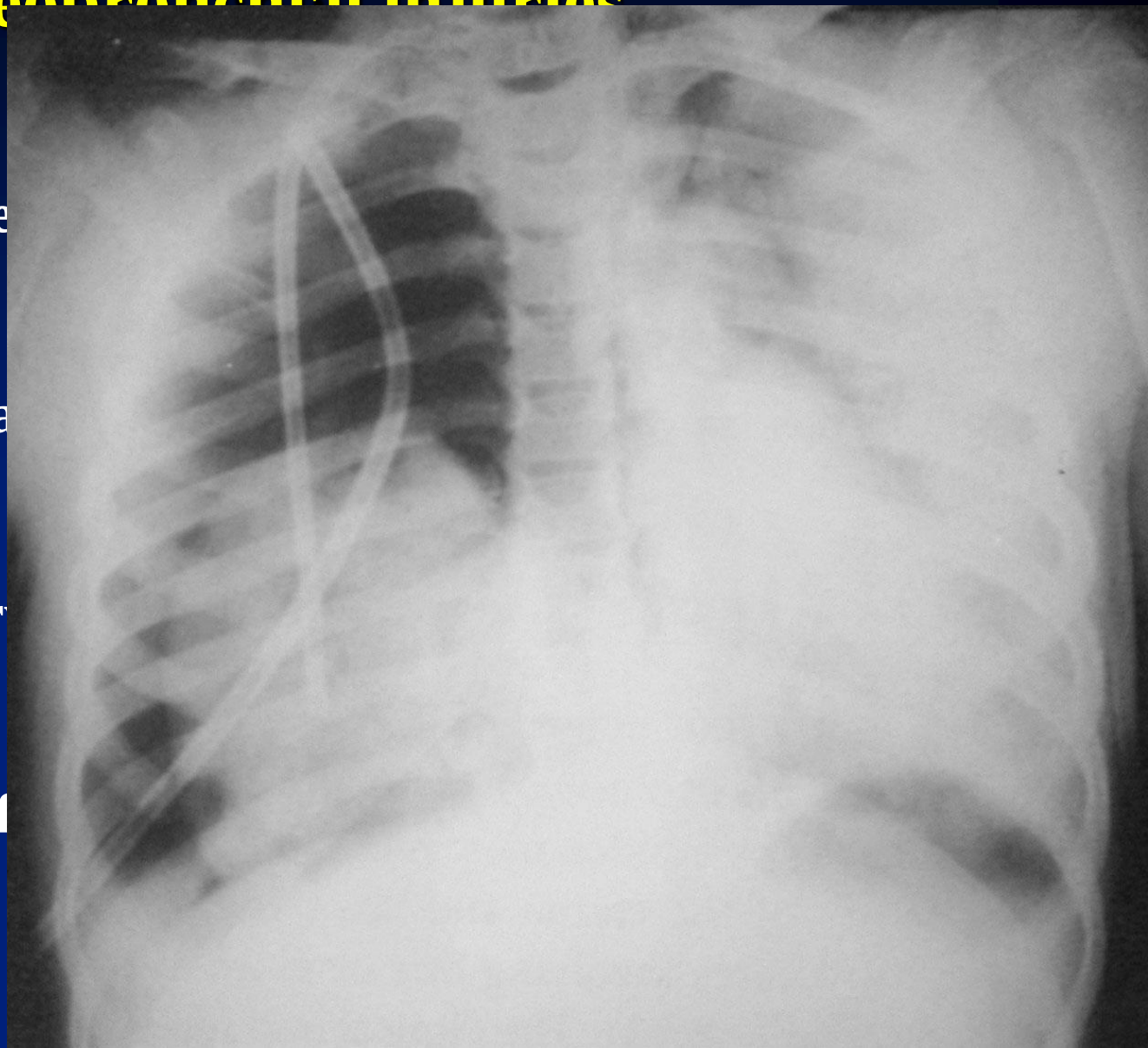




Après intubation

Tracheobronchial injuries

- Pneumomediastinum (pe
- Pneumothorax (pending
- « P » sign (pneumothora
- « Fallen lung » sign
- Interstitial air within air
- Ectopic location of ET
- Overdistention of ET cuf



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- Pneumomediastinum (pendi
- Pneumothorax (pending on l
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- « Fallen lung » sign
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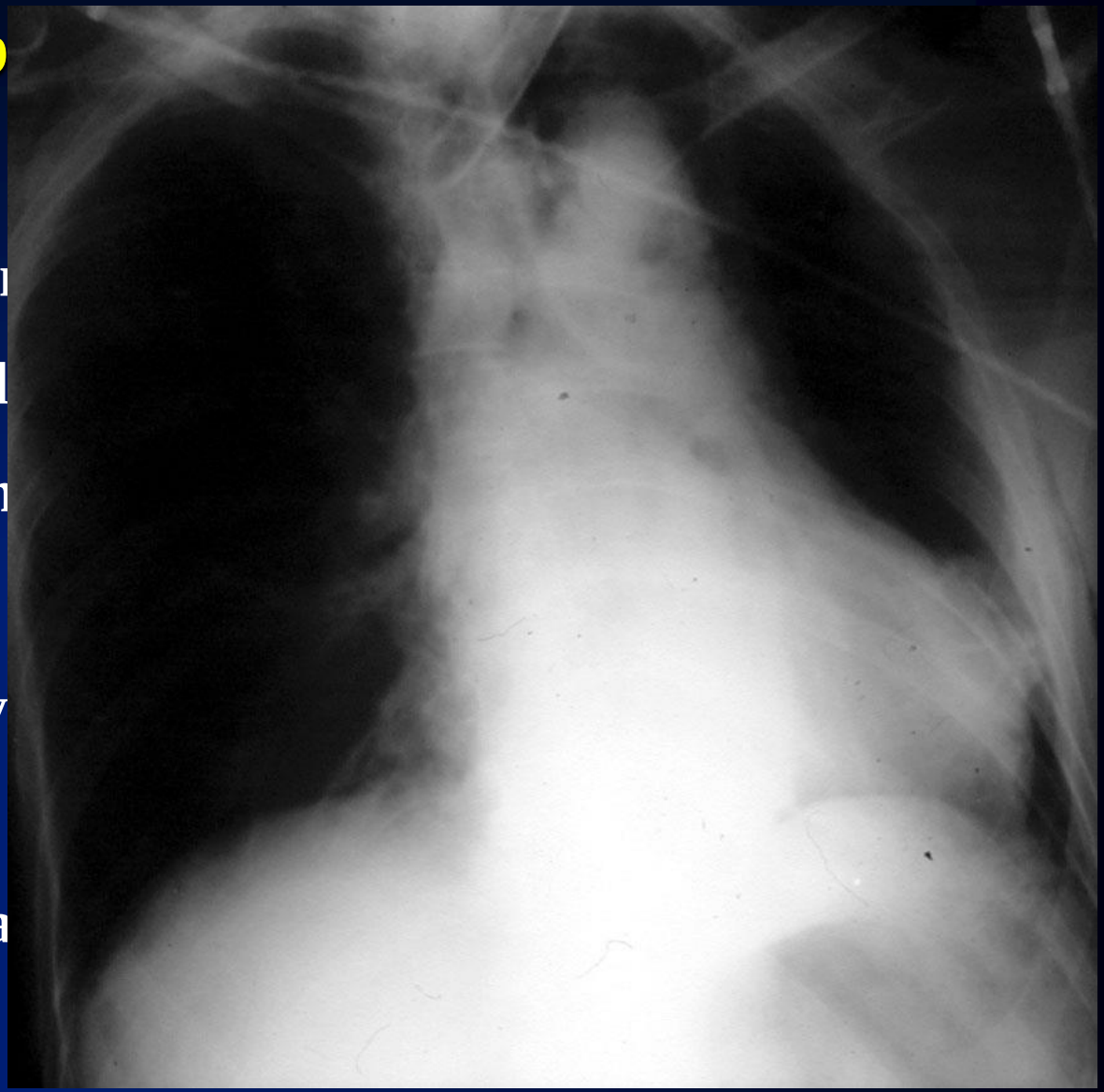
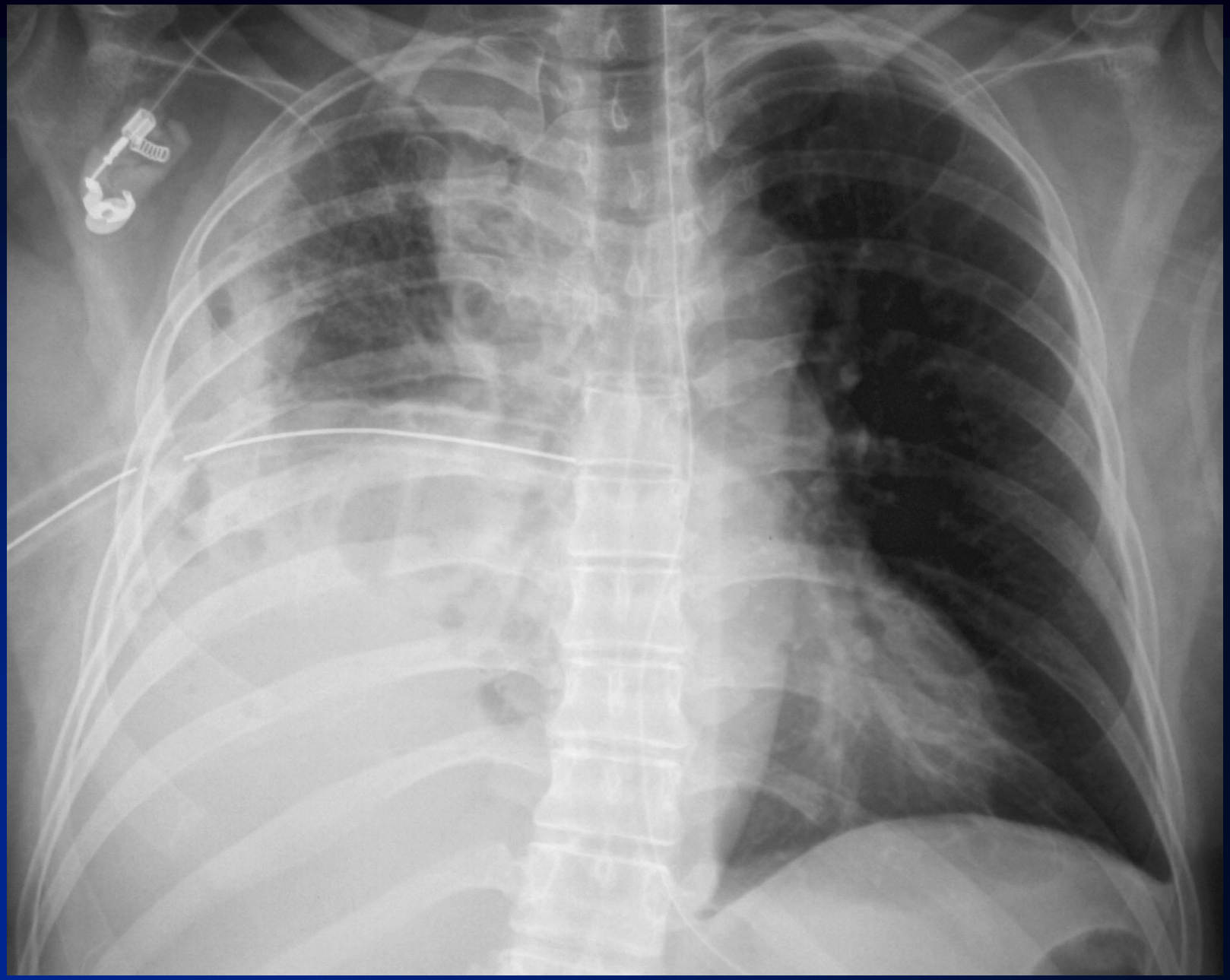
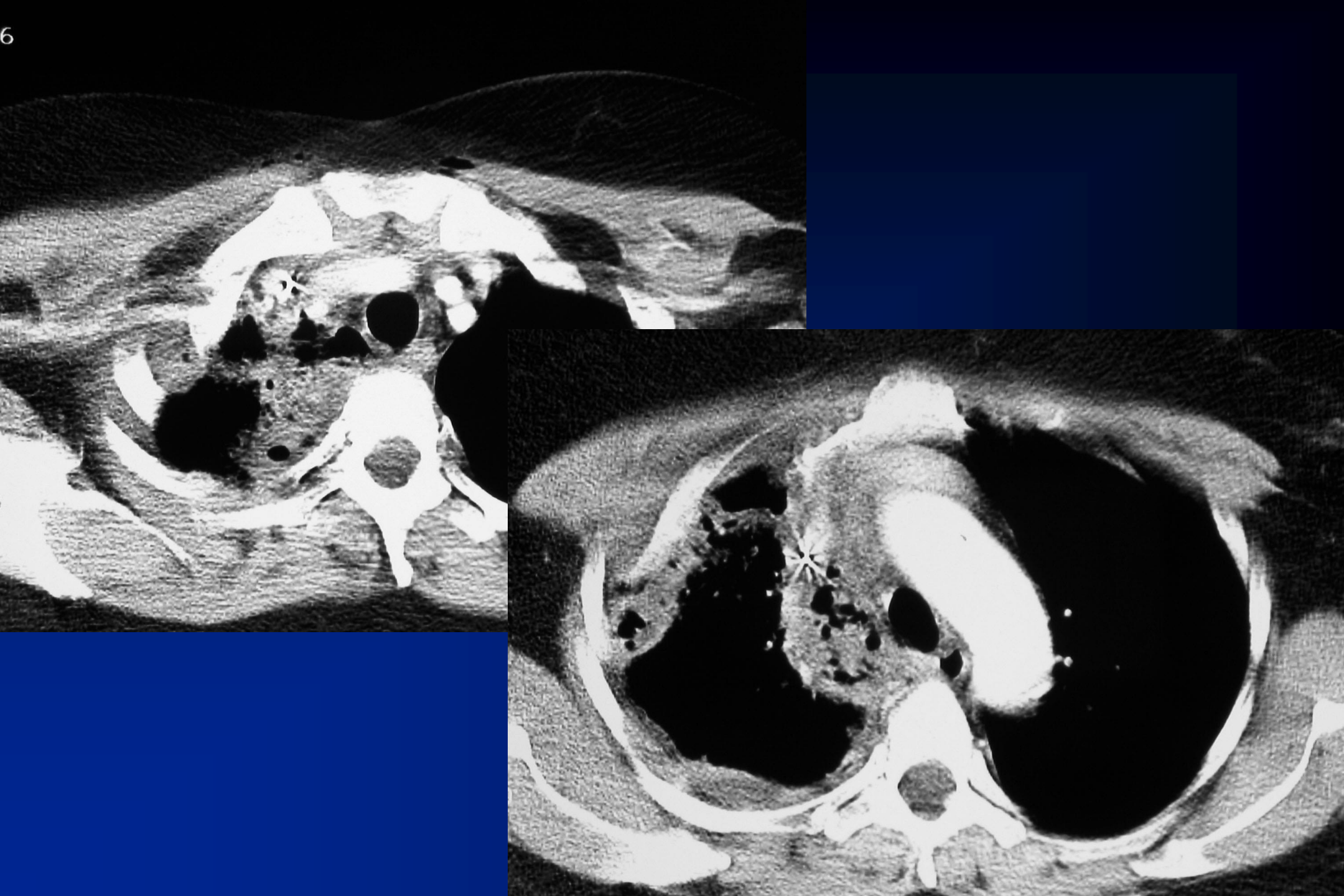
- Ectopic location of ET
- Overdistention of ET cuff ba

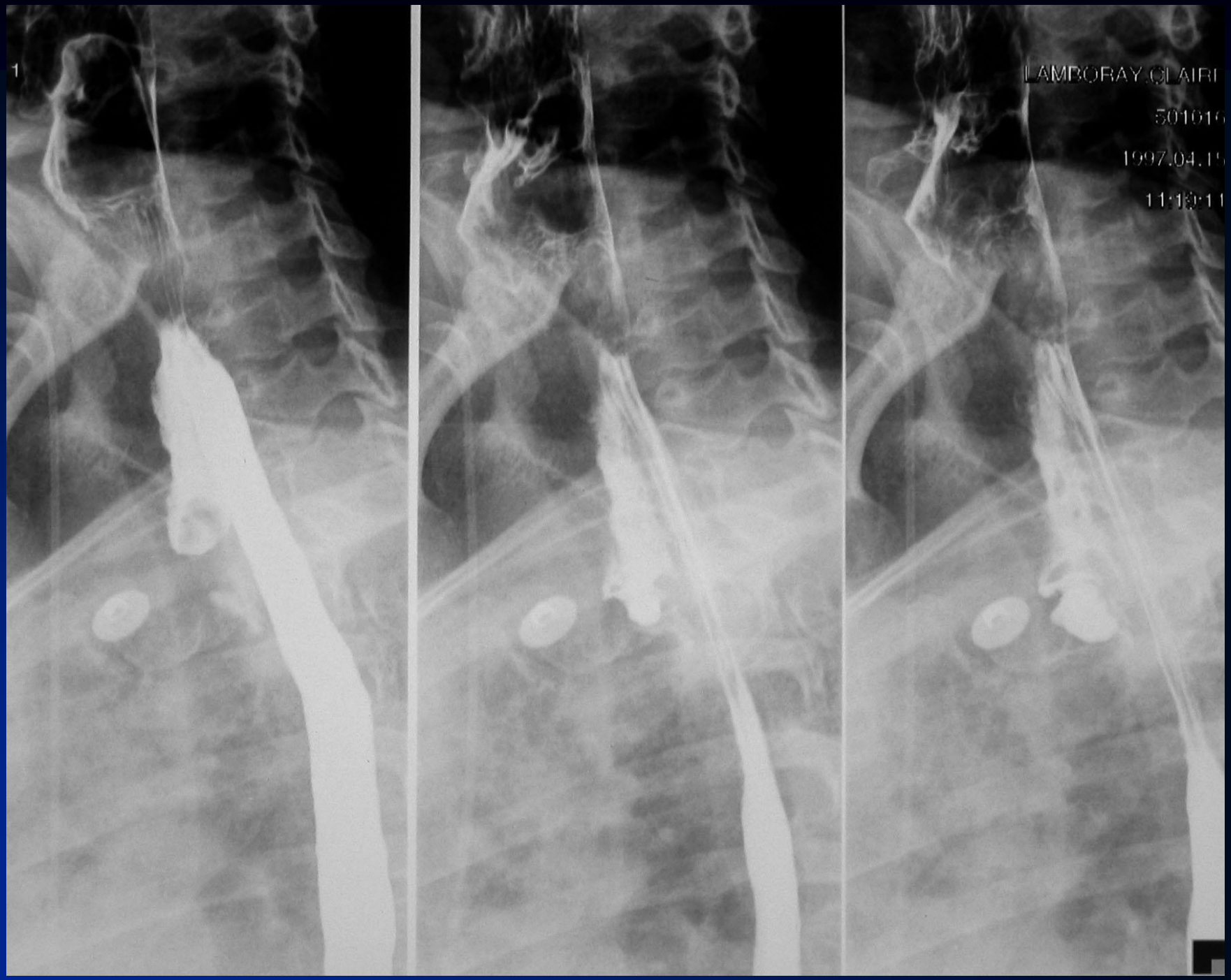


Esophageal Injuries

- < 1%
- Early diagnosis is imperative
- Mediastinitis
- Increase in esophageal pressure (stomach content)
- Tear: distal left postero-lateral wall
- Compression, traction, penetrating (bone #)
- Esophagram (non-ionic, barium)
- Endoscopy



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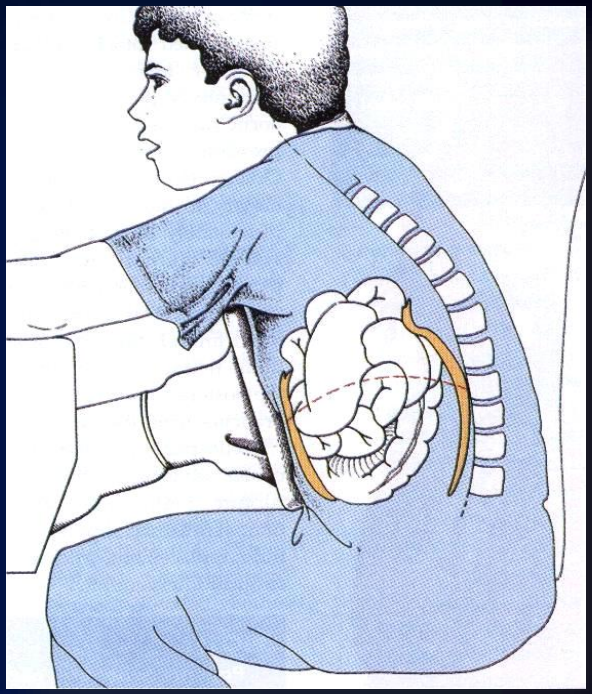
Cardiac Injuries

- Myocardial contusion (common 76 %, RV, CK-MB ↑), infarction, laceration, rupture
- Pericardial tamponnade (IP or EP), tear, rupture
- Cardiac herniation or dislocation
- Damage to the valve apparatus
- Coronary artery occlusion

Rupture diaphragmatique
Incidence des lésions et ruptures

- Incidence réelle inconnue (patients aΣ)
- Prévalence croissante dans la littérature
- 3 - 8 % des laparotomies post-trauma
- Autopsies: 5 - 17 % des polytraumas
- Estimation: 5-10 % des traumas sévères
- Pénétrant / fermé: 2/1 (3/1 à 1/8)
- Enfants ≈ adultes
- Fermé: 90 % après accident de roulage
  G > D (3/1)
  rarement bilatéral (3 %)
- Pénétrant: lésions dans 10-75 % des blessures Th/abd
  90 % lorsque du coté G
  G = D (1/1)



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Mueller and Pendarvis Emerg Radiol 1994; 1: 118-132
Iochum et al Radiographics 2002; 22;S103-S118

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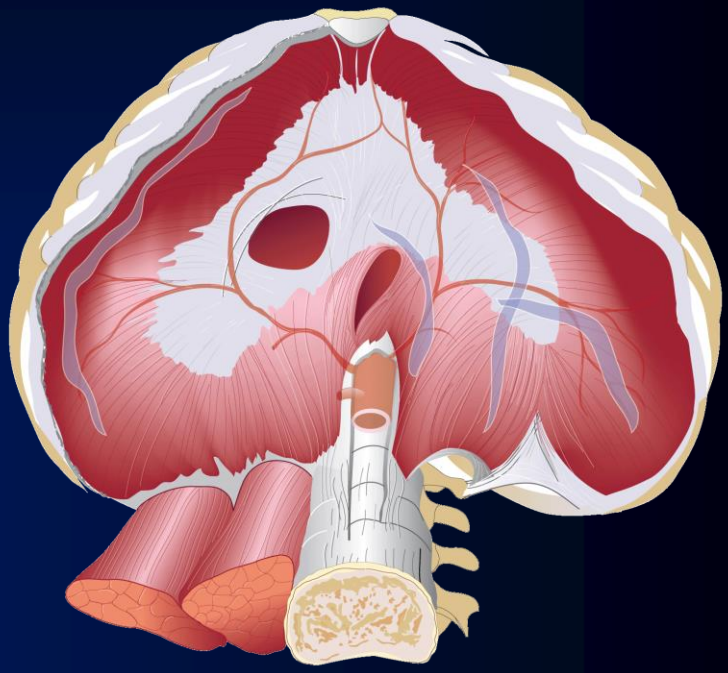

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Rupture diaphragmatique
Complications

- **Hernie**
  - **Viscère creux** (obstruction ou strangulation GI (délai: 80% endéans 3 ans (1j-48a), volvulus gastrique, ischémie GI)
  - **Organes solide** (conséquences moindre, ischémie, troubles fonctionnels)
- **Pulmonaires**
  - **Compression** (CV ↓, infection)
  - **Pneumo/hémo/urino/bilo/pyothorax, pseudokyste**
- **Cardiovasculaires**
  - **Tamponnade cardiaque**
  - **Obstruction veineuse centrale**
- **Autres**
  - **Splenosis intrathoracique, …**

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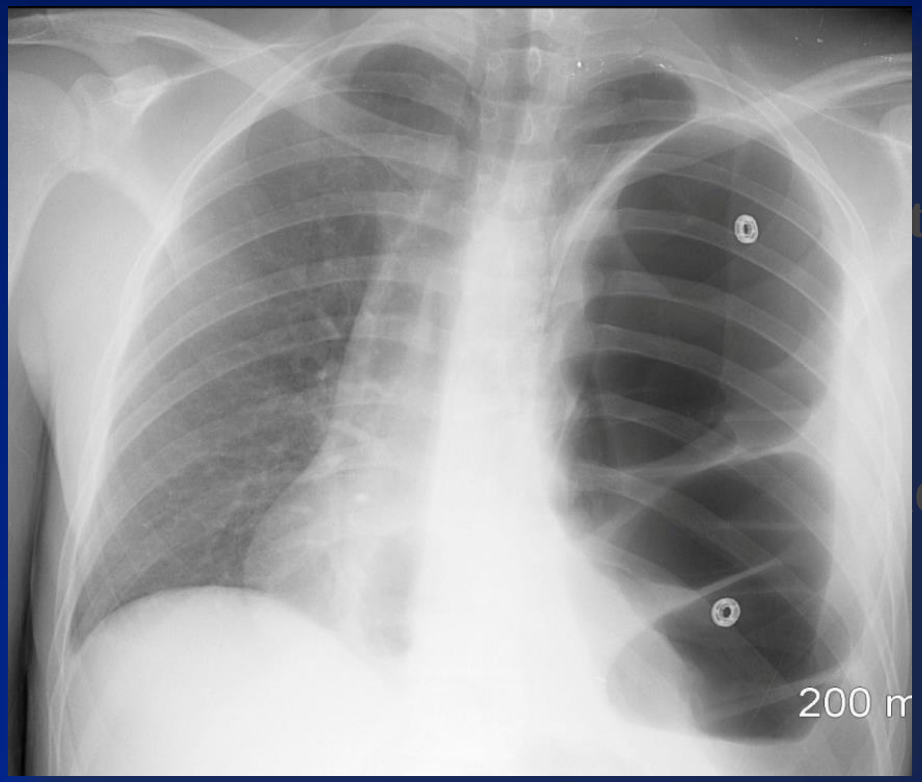

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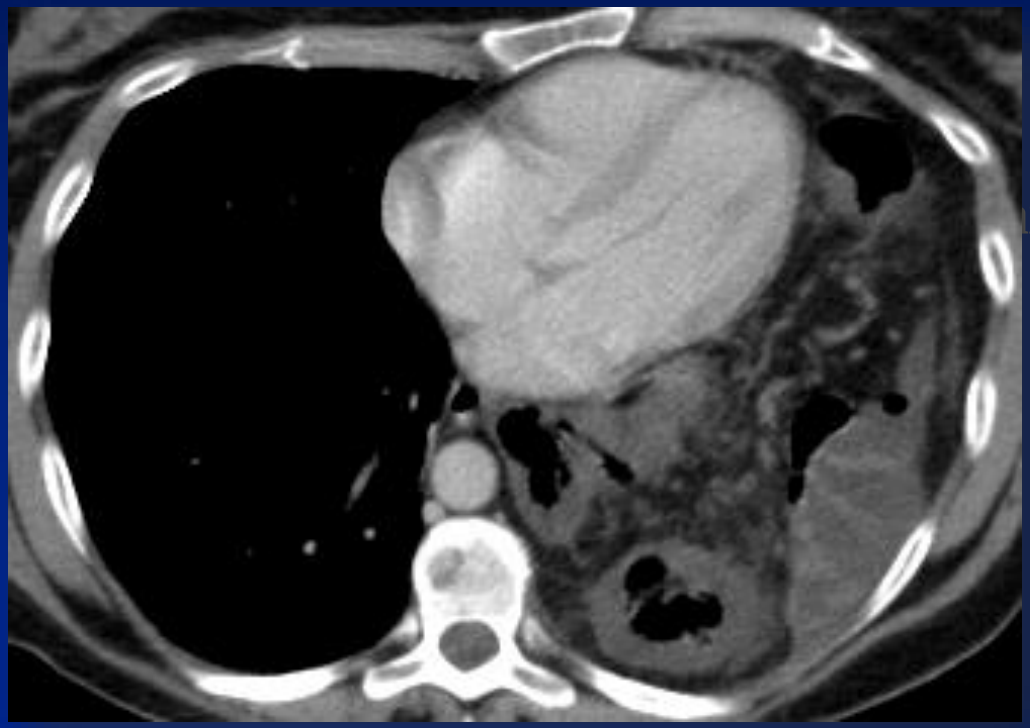


Signes TDM des ruptures diaphragmatiques

SIGNES DIRECTS
… un trou dans le diaphragme

1. Signe du défect segmentaire
2. Signe du diaphragme ballant
3. Signe du diaphragme absent[1]

SIGNES DIVERS

16. Signe du diaphragme épaissi[5]
17. Extravasation (péri-) diaphragmatique de produit de contraste
18. Signe du diaphragme hyporehaussant
19. Signe du fragment costal [6]

SIGNES INDIRECTS
… liés à la hernie

4. Hernie à travers le défect
5. Signe du collet[2, 3]
6. Signe de la bosse
7. Signe de la bande
8. Signe du viscère dépendant
9. Signe de l'interruption du sinus
10. Contenu abdominal périphérique au diaphragme ou au poumon
11. Organes intra-abdominaux surélevés[4]

SIGNES INDIRECTS
…liés à l'absence de frontière entre le thorax et l'abdomen

12. Liquide abdominal en contact avec un élement thoracique
13. Liquide thoracique en contact avec un élement abdominal
14. Pneumothorax et -péritoine
15. Haemothorax et -péritoine

Egalement appelé:
1: Non visualisation segmentaire du diaphragme
2: Signe du sablier
3: Signe du champignon
4: Elévation apparente du diaphragme
5: Signe du diaphragme ondulé
6. Lacération du diaphragme par une côte

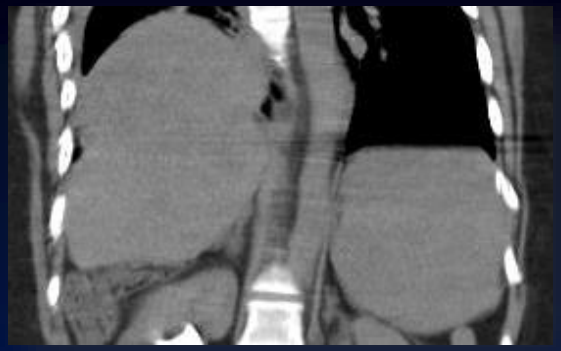
Desir and Ghaye. RadioGraphics 2012 32: 477-498

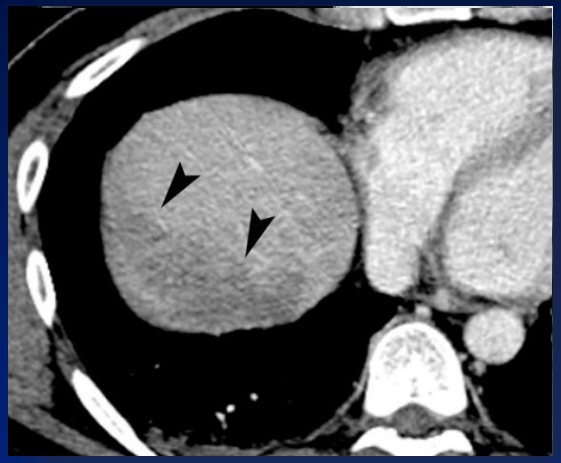
1. Signe du défect segmentaire

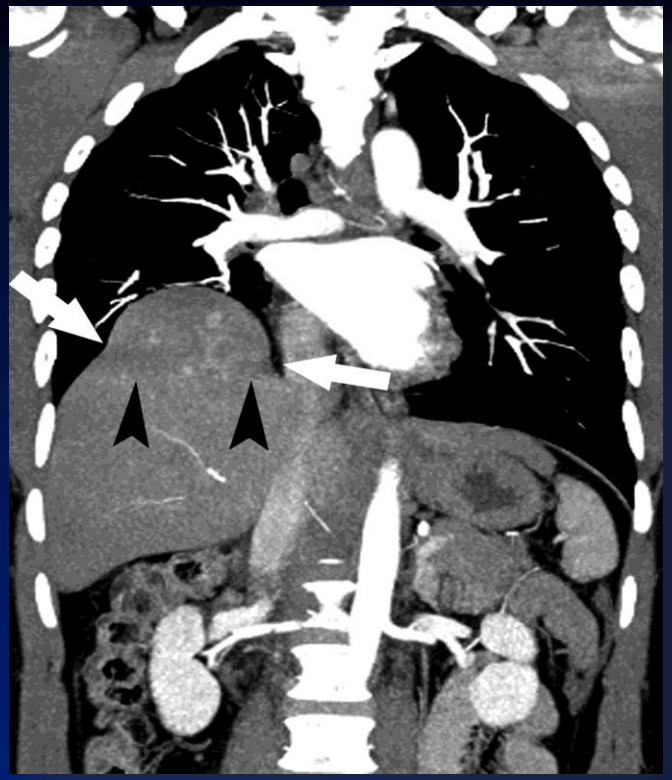
Perte de continuité focale et abrupte du diaphragme

Sens : 17-80% (D: 16-66% , G: 22-87%)
Spéc : 90-100%

Heiberg et al. AJR 1980;135:369-72
Holland et al. AJR 1991;157:17-8
Nchimi et al. AJR 2005;184:24-30







6. Signe de la bosse

7. Signe de la bande

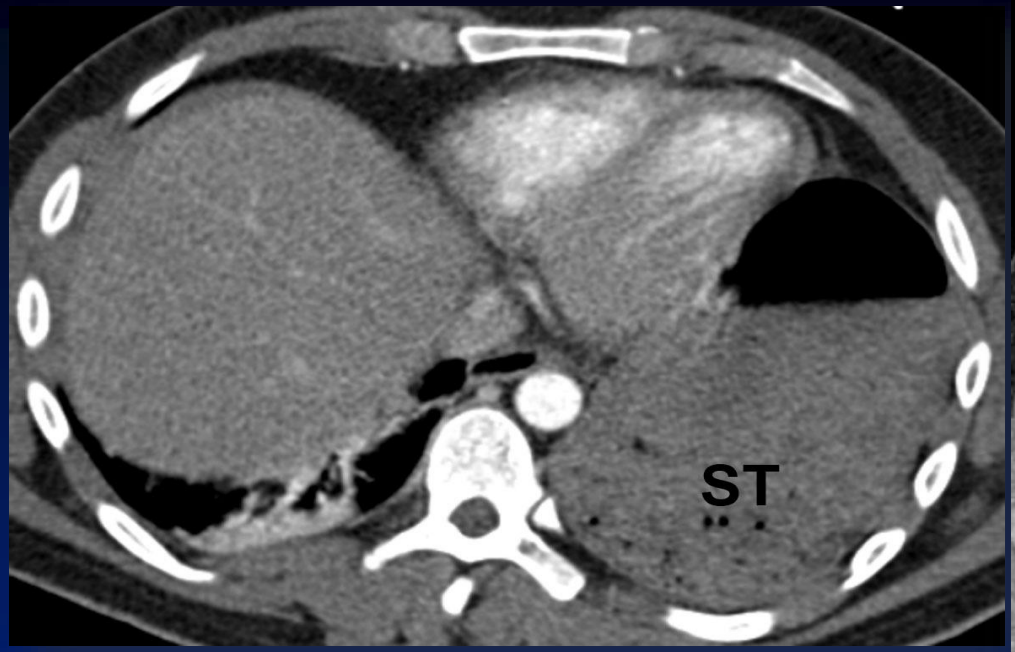
Le signe bosse est une variation du signe de collet sur le côté D, la bosse terme faisant référence à la forme du foie hernie au-dessus du niveau du diaphragme

Le signe de la bande correspond à une zone hypodense transversale linéaire traversant le foie hernié, située entre les bords du diaphragm rompu.

Sens : 50-83%

Sens : 33-42%

Rees O. et al. Clin Radiol 2005;60(12):1280-9

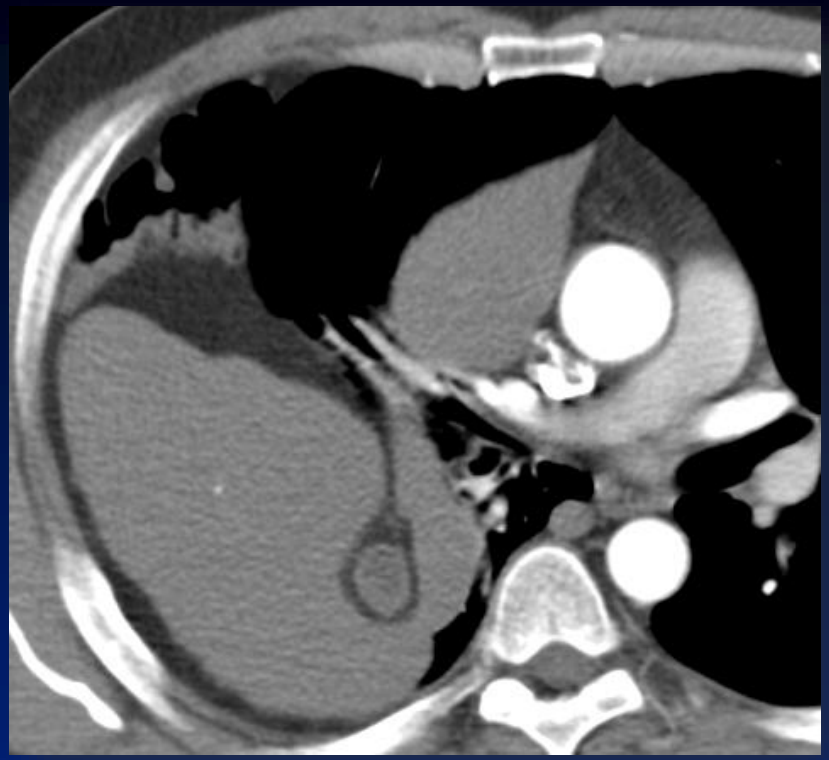
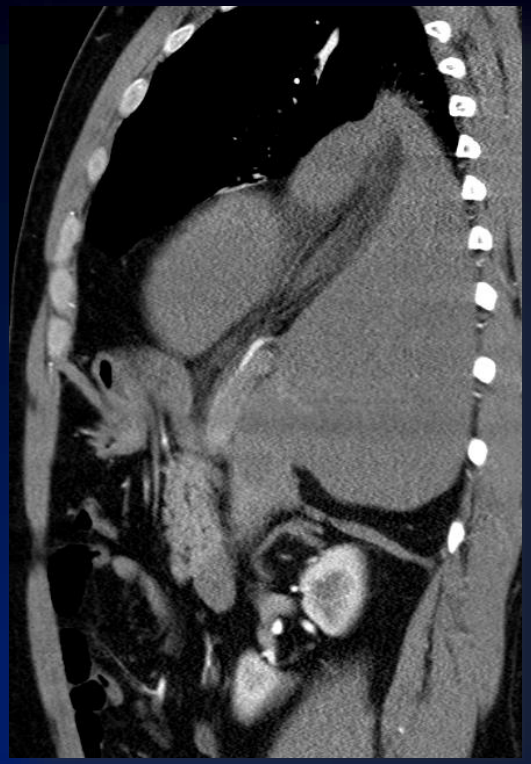


8. Signe du viscère dépendent

Contact direct des organes abdominaux herniés contre la paroi thoracique postérieure sans interposition de poumon.
La perte du soutien diaphragmatique après une rupture peut conduire
à la chute des organes abdominaux dans une position déclive,
à savoir contre la paroi thoracique postérieure lorsque le patient est en décubitus dorsal.

Sens : 54-90% (D: 33-83%, G: 64-100%)
Spéc : 98-100%

Bergin D, et al. AJR 2001;177(5):1137-40.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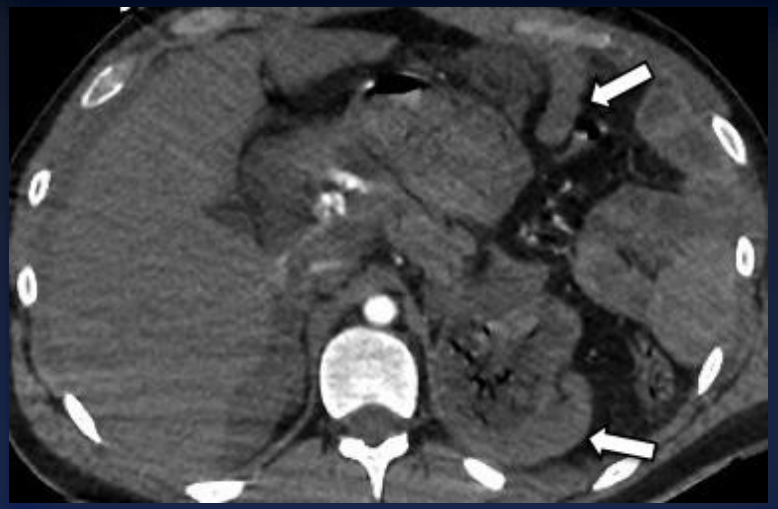
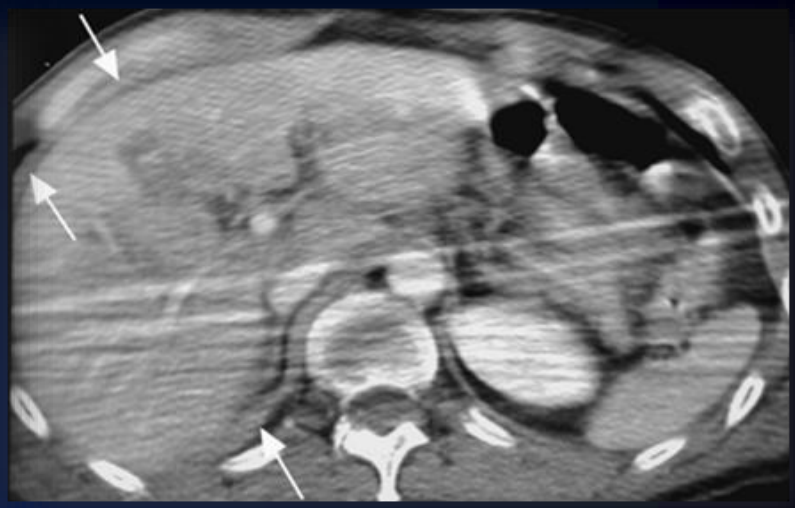



16. Signe du diaphragme épaissi

Epaississement anormal régulier ou nodulaire, focal ou diffus du diaphragme
Résultante de la rétraction des berges du diaphragme rompu

Sens : 56-75% (D: 50-100%, G: 36-68%)
Spéc : 95%

Leung et al. JTI 1999;14:126-9
Koplewitz et al. Pediatr Radiol 2000;30:471-9

Ruptures diaphragmatiques
Difficultés diagnostiques

- **TDM séquentielle:** **sensibilité : 14-61 %**
  spécificité : 76-99 %
- **TDM hélicoïdale:** **sensibilité : 42-90 % (most retrospective)***
  R : 50-83 %
  L : 78-100 %
  spécificité : 77-100 %
- **TDM multidétecteurs:** **sensibilité : 77%****
  spécificité : 98%

- **Agrément interobservateur: K = 0.3-0.97%**

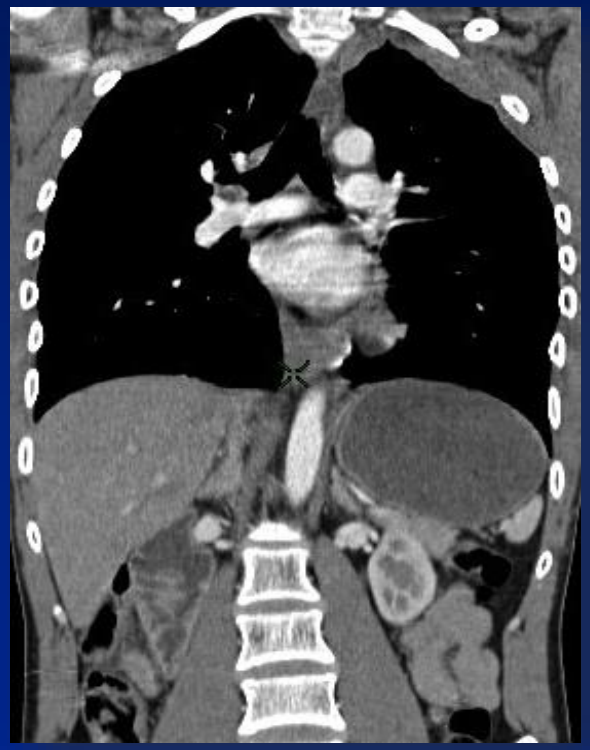
Killeen et al AJR 1999;173:1611-1616
Bergin et al. AJR 2001;177:1137-1140
Larici et al AJR 2002;179:451-457

*Nchimi et al AJR 2005;184:24-30
**Desser et al Emerg Radiol 2010;17:37-44

TDM multidétecteurs

Résultats (n=42)

- **Sensibilité de la TDM (16 à 256 rangées de détecteurs):**
  - **41/42 (97,6%) >< 71-90% de la littérature**
  - **1 cas de rupture diaph G non détectée**



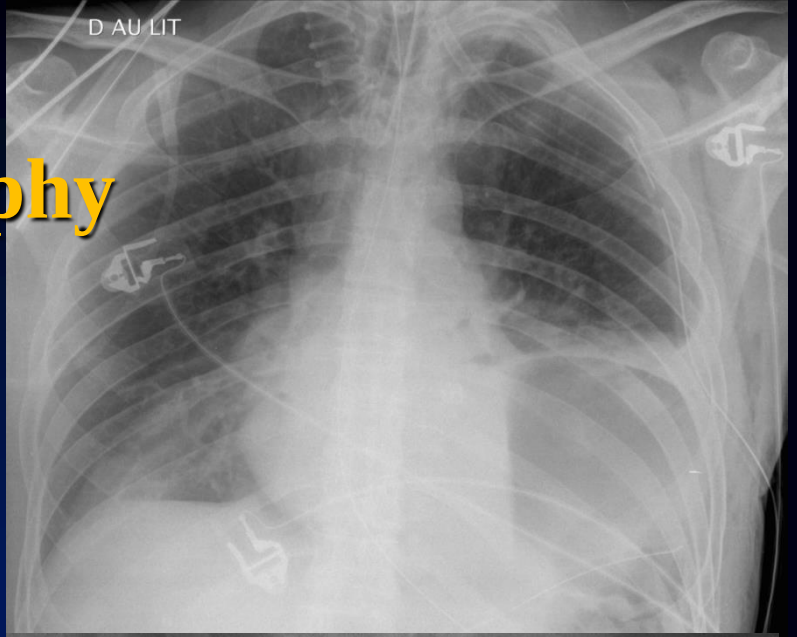
Desser TS, et al. Emerg Radiol 2010;17(1):37-44
Bergin D, et al. AJR Am J Roentgenol 2001;177(5):1137-40
Killeen KL, et al. AJR 1999;173(6):1611-6

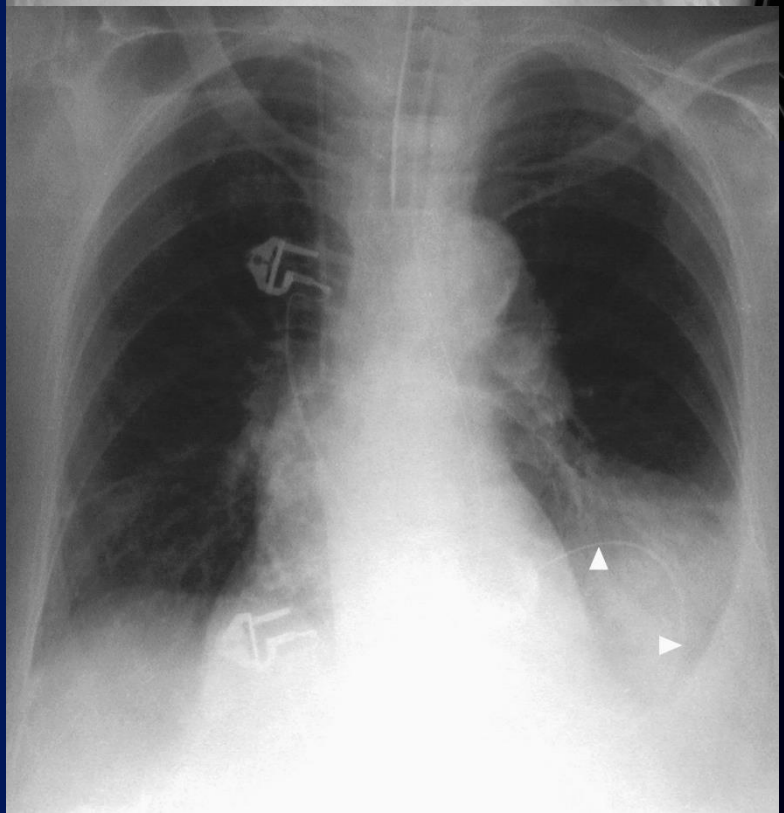
Imaging
Plain radiography

- Full inspiration chest X-ray
- Insertion of nasogastric tube
- Diagnostic or highly suggestive signs
  - viscera above diaph
  - aN high diaph > 6 cm
  - tip of NG above diaph

- Suggestive signs
  - aN high diaph < 6 cm
  - obscuration of diaph
  - mediastinal shift, pleural effusion, aN heart shadow

Gelman et al AJR 1991;156:51-57





ABCs of Thoracic Trauma

- **A Aortic injuries**
- **B Bronchial and tracheal injuries**
- **C Cord and spinal injuries**
- **D Diaphragm injuries**
- **E Esophageal injuries**
- **F Fractures**
- **F Flail chest**
- **G Gas**
- **H Heart and pericardium**
- **H Hemothorax, hematoma, hemorrhage**
- **I Iatrogenic injuries**

Gurney JW et al. 1996
www.chestx-ray.com