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Life-threatening thoracic injury

Division of Trauma Surgery, Department of thoracic and cardiovascular surgery

Head of Trauma Center, Dankook University Hospital

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흉부외과 전공의 연수강좌 - 외상

2025
* Life-threatening thoracic injury
* Damage Control and definitive surgery for thoracic and chest wall injury
2026
* Life-threatening cardiovascular injury and resuscitative thoracotomy
* Damage Control and definitive surgery for cardiovascular injury
2027
* Advanced Trauma Life Support(ATLS) - all trauma care
* Damage Control Resuscitation

Introduction

- Directly responsible for more than 20% of all traumatic deaths
- Lung parenchymal injury was occurred in 25% of chest trauma
- 8-40 % of patients: treated with tube thoracostomy alone
- Blunt thoracic injuries

  : Forces distributed over a large area – Deceleration, Compression
- Penetrating thoracic injuries

  : Forces are distributed over a small area.

  Organs injured - the path of the penetrating object

❖ Life-Threatening injuries - THORAX

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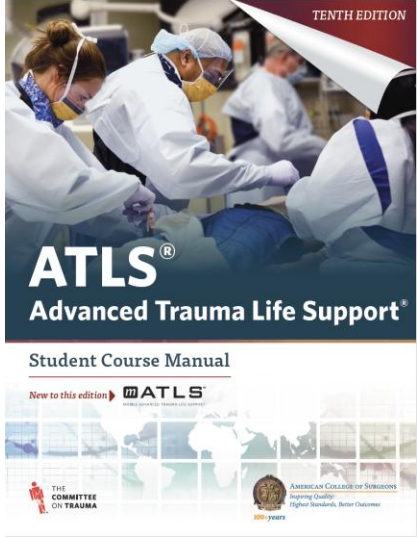
Objectives



- Identify and initiate treatment of the following injuries

OBJECTIVES

After reading this chapter and comprehending the knowledge components of the ATLS provider course, you will be able to:

1. Identify and describe treatment of the following life-threatening injuries during the primary survey: airway obstruction, tracheobronchial tree injury, tension pneumothorax, open pneumothorax, massive hemothorax, and cardiac tamponade.

2. Identify and describe treatment of the following potentially life-threatening injuries during the secondary survey: simple pneumothorax, hemothorax, flail chest, pulmonary contusion, blunt cardiac injury, traumatic aortic disruption, traumatic diaphragmatic injury, and blunt esophageal rupture.

3. Describe the significance and treatment of subcutaneous emphysema, thoracic crush injuries, and sternal, rib, and clavicular fractures.

Immediately life-threatening injuries

- Many patients with thoracic injuries: death after visiting the hospital
- Could be prevented with prompt diagnosis and treatment
- Due to: Hypovolemia, Hypoxia, Hypercarbia, Acidosis
- Initial assessment and treatment
    - Primary survey and resuscitation

Primary survey

- Airway
- Breathing
- Circulation
- Disability
- Exposure

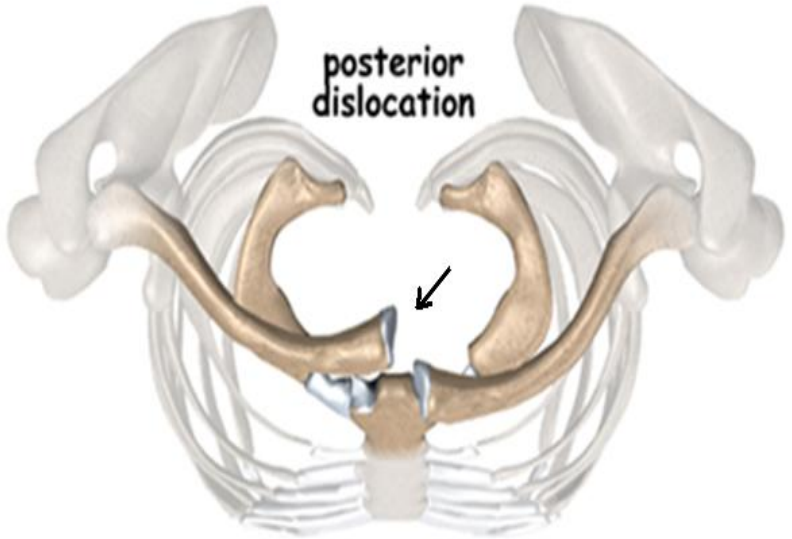
- You must treat hypoxia in your primary survey, if no airway and oxygenation established, do not move on to your secondary survey!

Airway

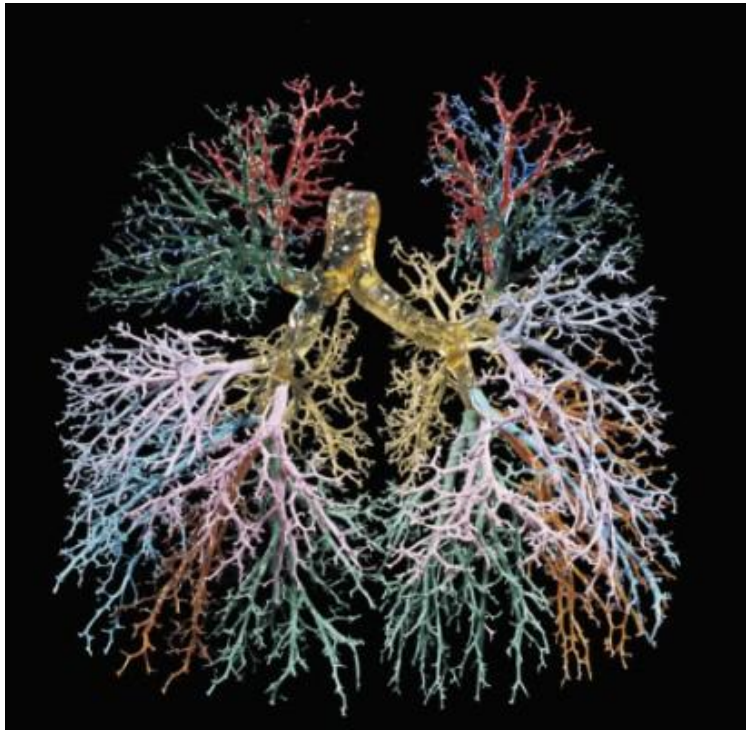
- Major injury affecting the airway
- Patency and air exchange
    1) Listening for air movement
    2) Inspecting the oropharynx for foreign-body obstruction
    3) Observing for intercostal and subclavicular muscle retractions.
- Laryngeal injury ➔ Airway part

Injury to the upper chest

- Palpable defect in the region of sternoclavicular joint
- PEx: Stridor, marked change of voice
- Dx: Posterior dislocation of the clavicular h
  - ➔ Upper airway obstruction
- Tx: Reduction



Tracheobronchial tree injury

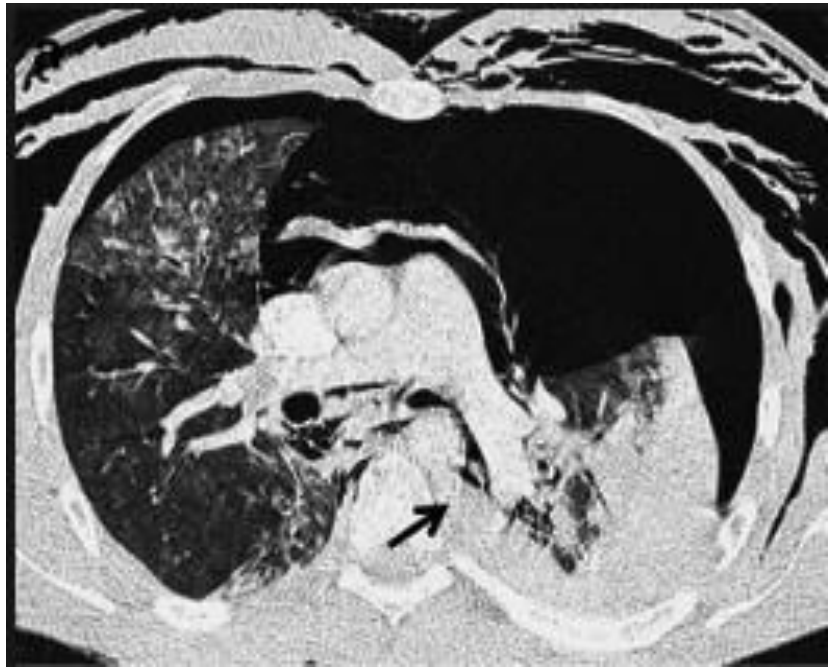


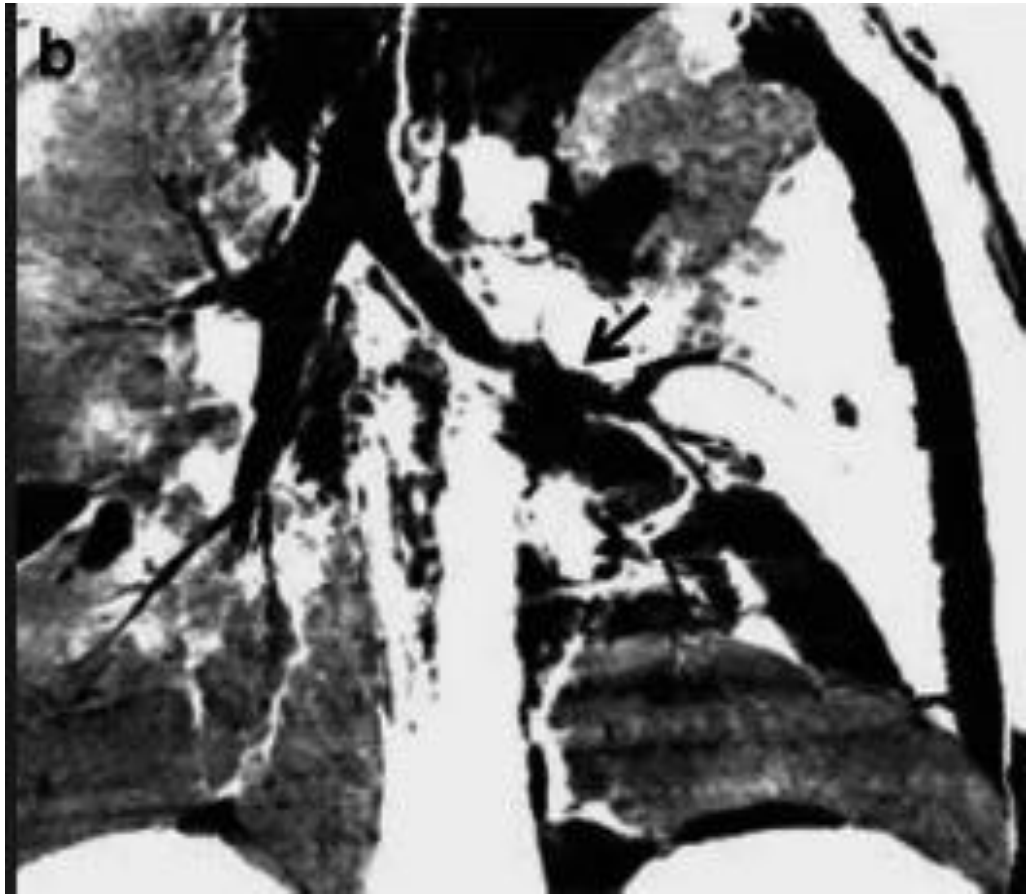
- Unusual but potentially fatal condition
- Blunt trauma: within 1 inch of the carina
- Most patient: die at scene
- Sign and Sx: Hemoptysis, subcutaneous emphysema, tension pneumothorax

  Incomplete expansion of the lung after closed thoracostomy
- Suspicion: Continuous and massive air leakage
- More than one chest tube often is necessary to overcome a severe air leak

- Dx: Bronchoscopy
- Suspected ➔ immediate surgical consultation
- Temporary intubation of opposite mainstem bronchus
- Tx: Immediate operation

  Stable V/S case ➔ may be delayed





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Check for updates

Heparin-free extracorporeal membrane oxygenation in a patient with severe pulmonary contusions and bronchial disruption

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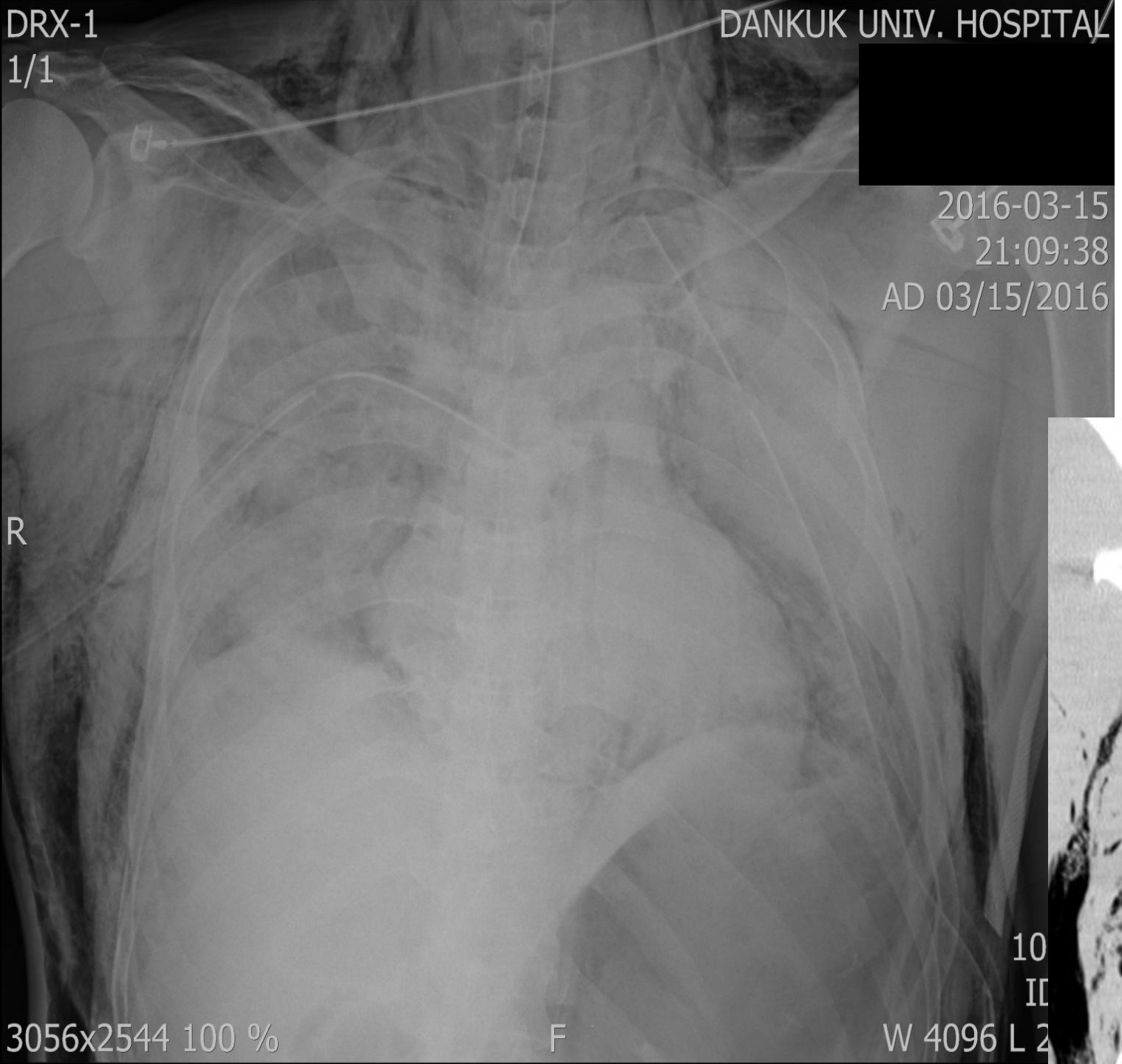
Case

- M/35
- 지게차와 벽사이에 끼이는 사고
- XX 병원: Respiratory arrest ➔ CPR (5min)

  Bilateral closed thoracostomy 후 전원됨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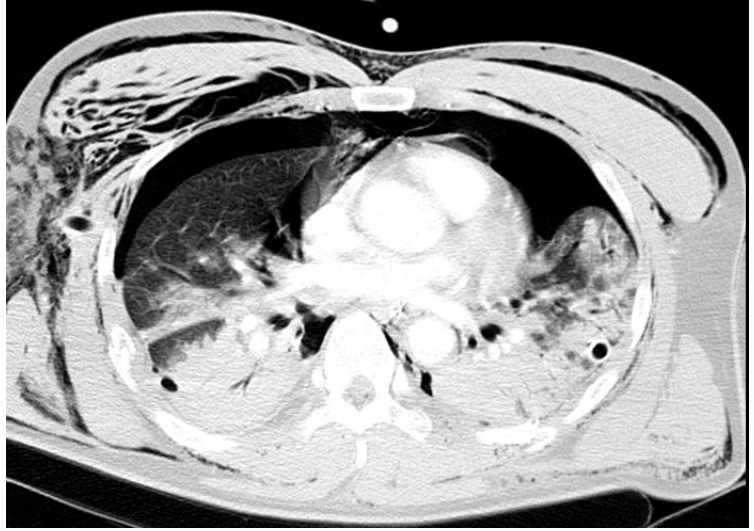
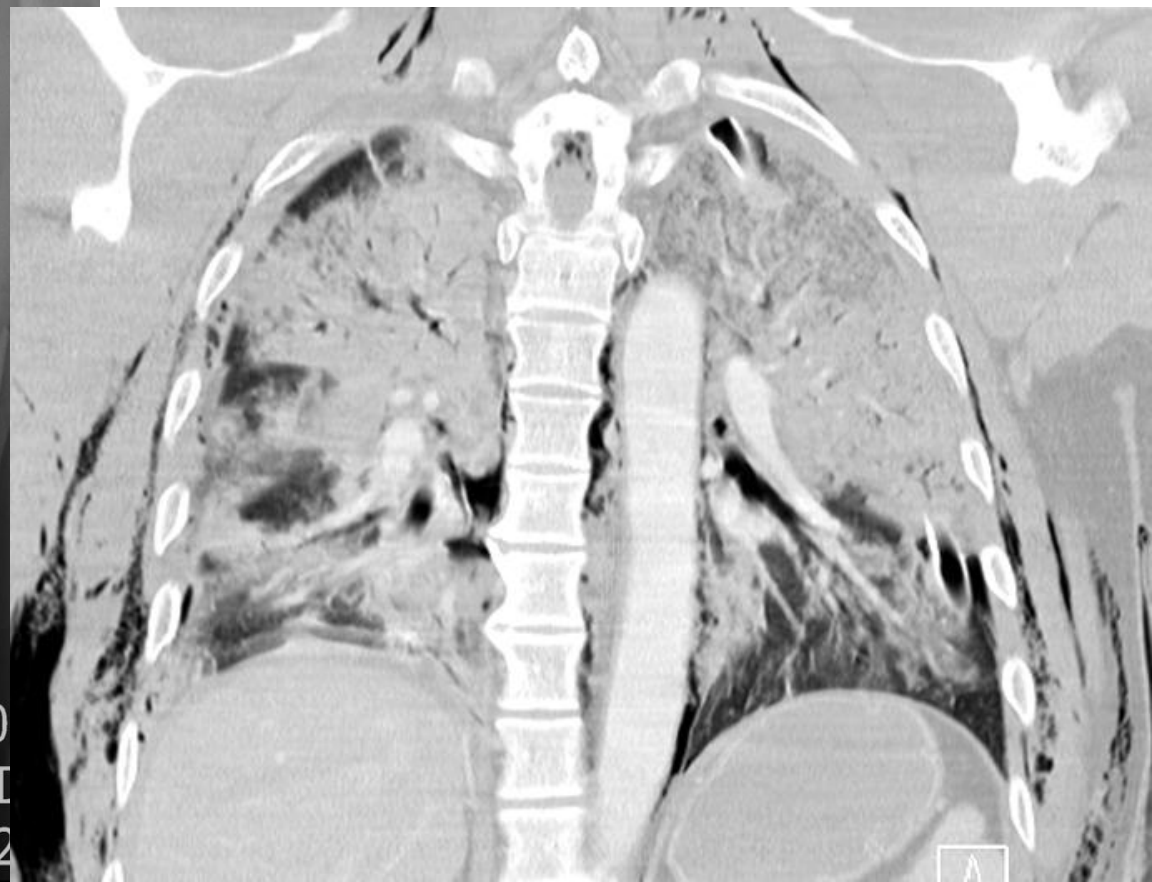




Progression note

◆ Initial V/S and ABGA

- 160/100 mmHg– 104/min – 32/min – 92%

- 7.22 – 59 – 64 – 87%

◆ One more C-thoracostomy (32Fr) on Rt. Side

- 124/75 – 103/min – 19/min – 100%

- 7.40 – 33 – 83 – 96%

◆ ICU transfer

◆ ICU management

- PC-SIMV mode, Pip:26, PEEP:7, RR:20/min, FiO_2 0.5

- ABGA 7.30 – 55 – 87 – 96%

- Rt.: Continuous and massive air leakage, Lt.: Air leakage

◆ 8 hour later (2016-03-16 06:00), BP and Saturation fluctuation

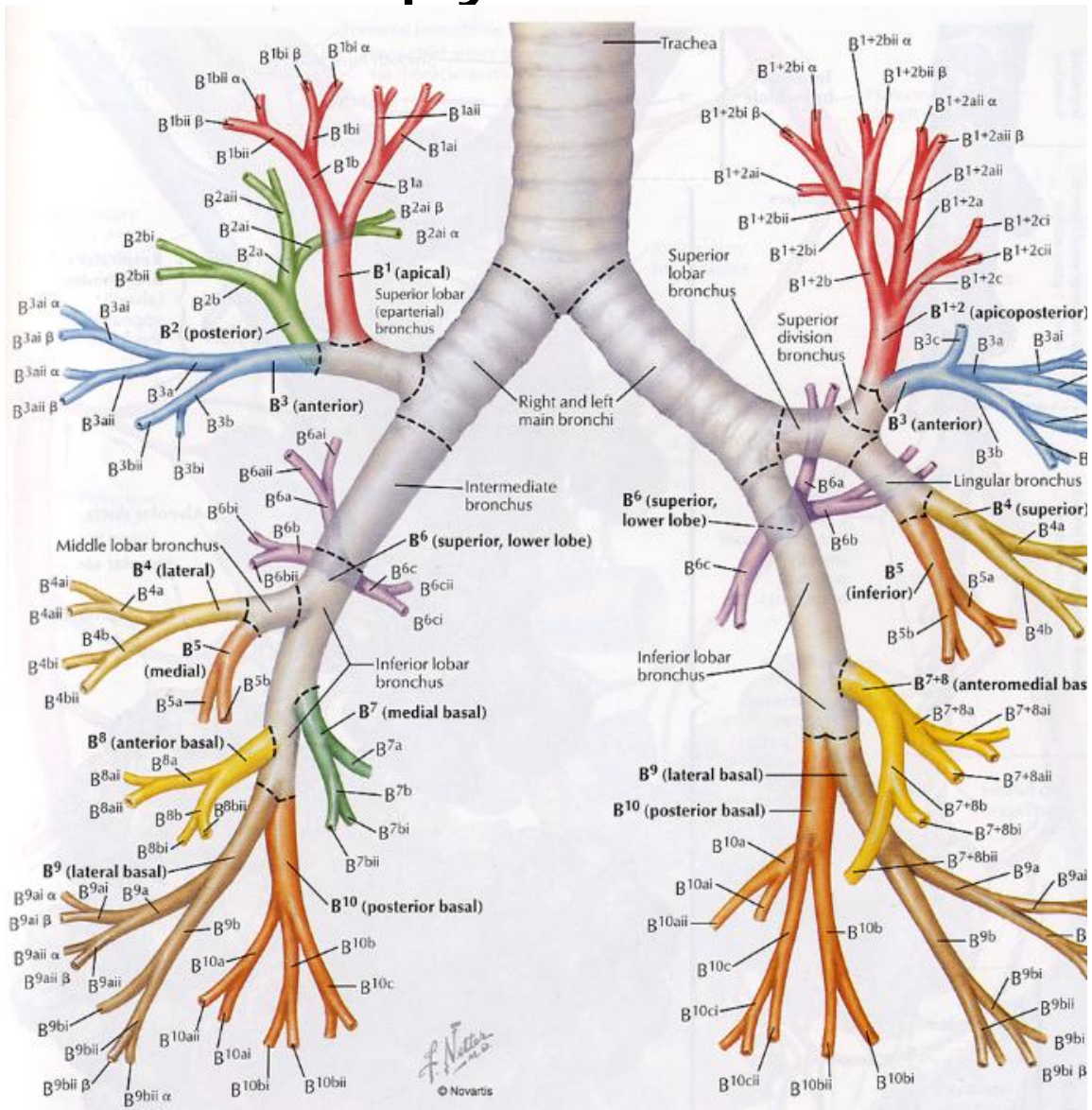
- PC-SIMV mode, Pip:30, PEEP:10, RR:24/min, FiO_2 0.9

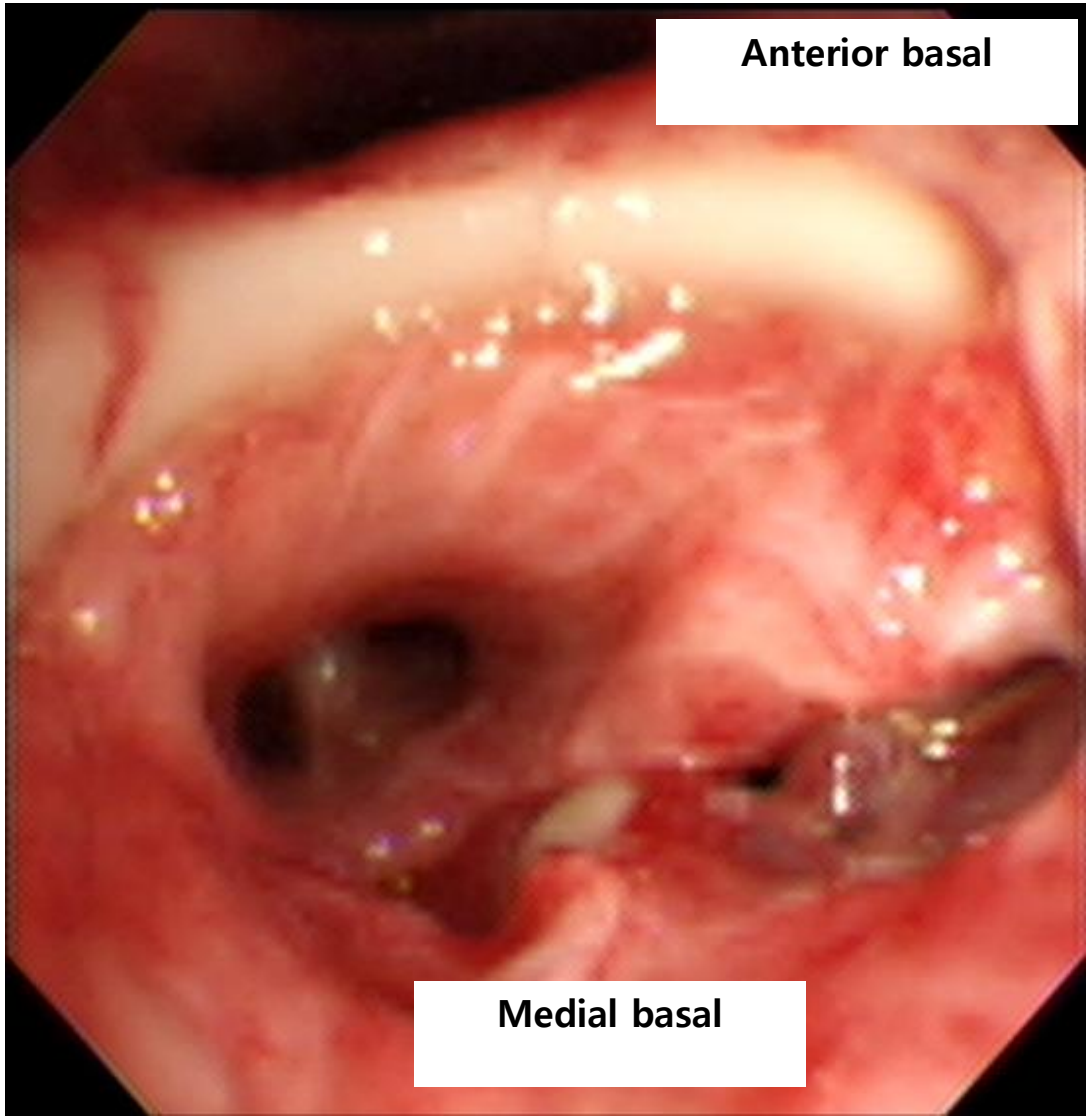
- ABGA 7.30 – 56 – 82 – 95%, P/F ratio: 91

- 100/55 – 120/min – 26/min – 100%

1st ECMO ➔ 2nd Bronchochoscopy ➔ prn) Operation

Bronchoscopy under Veno-venous ECMO support



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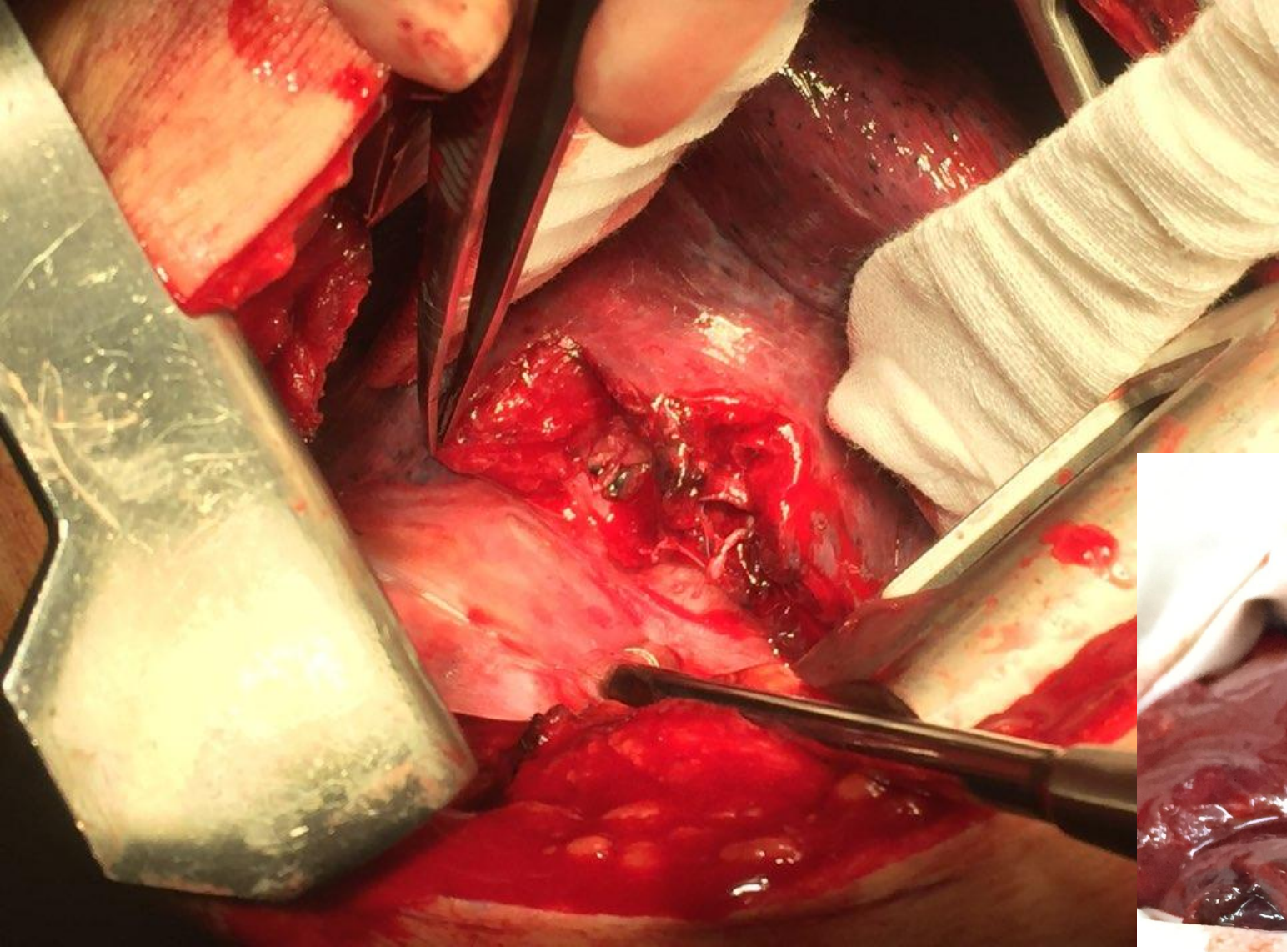

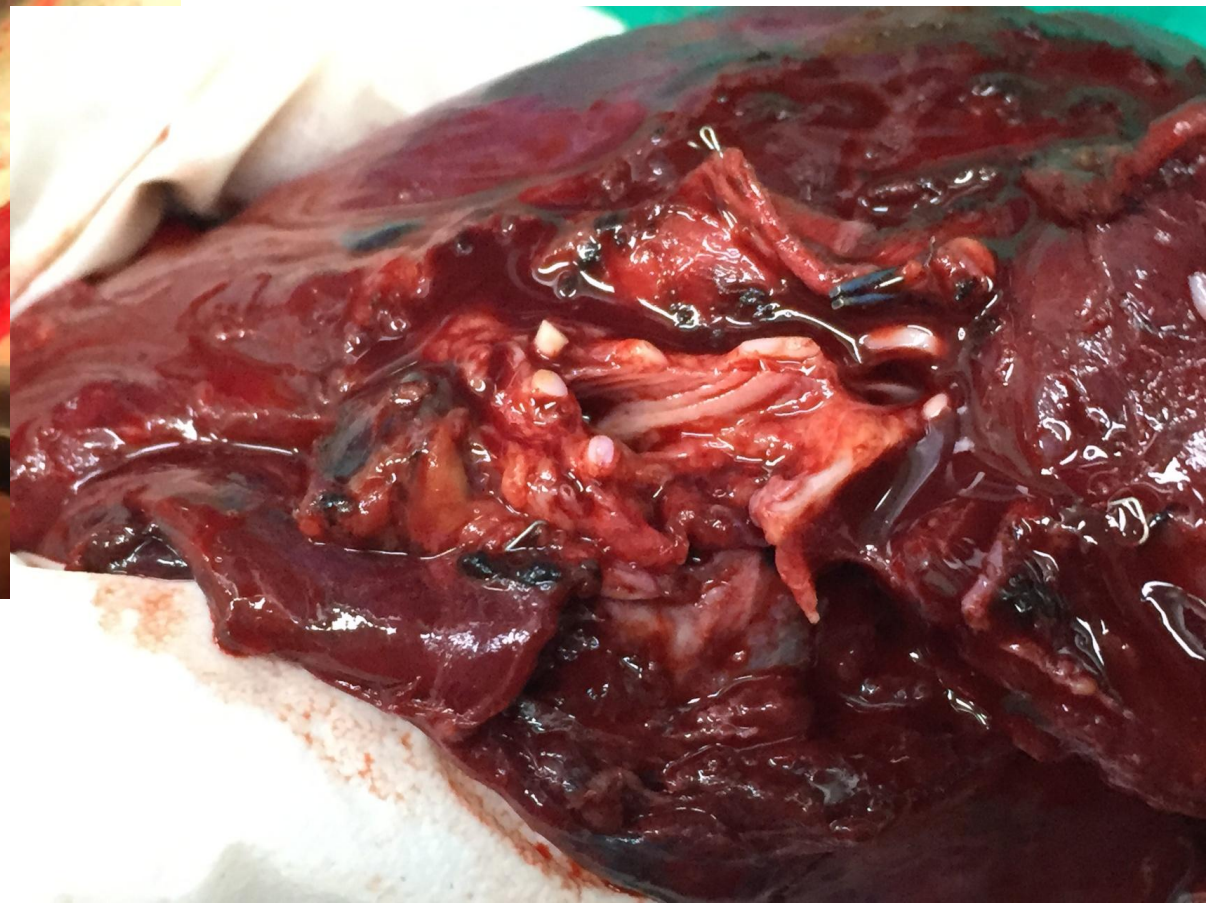

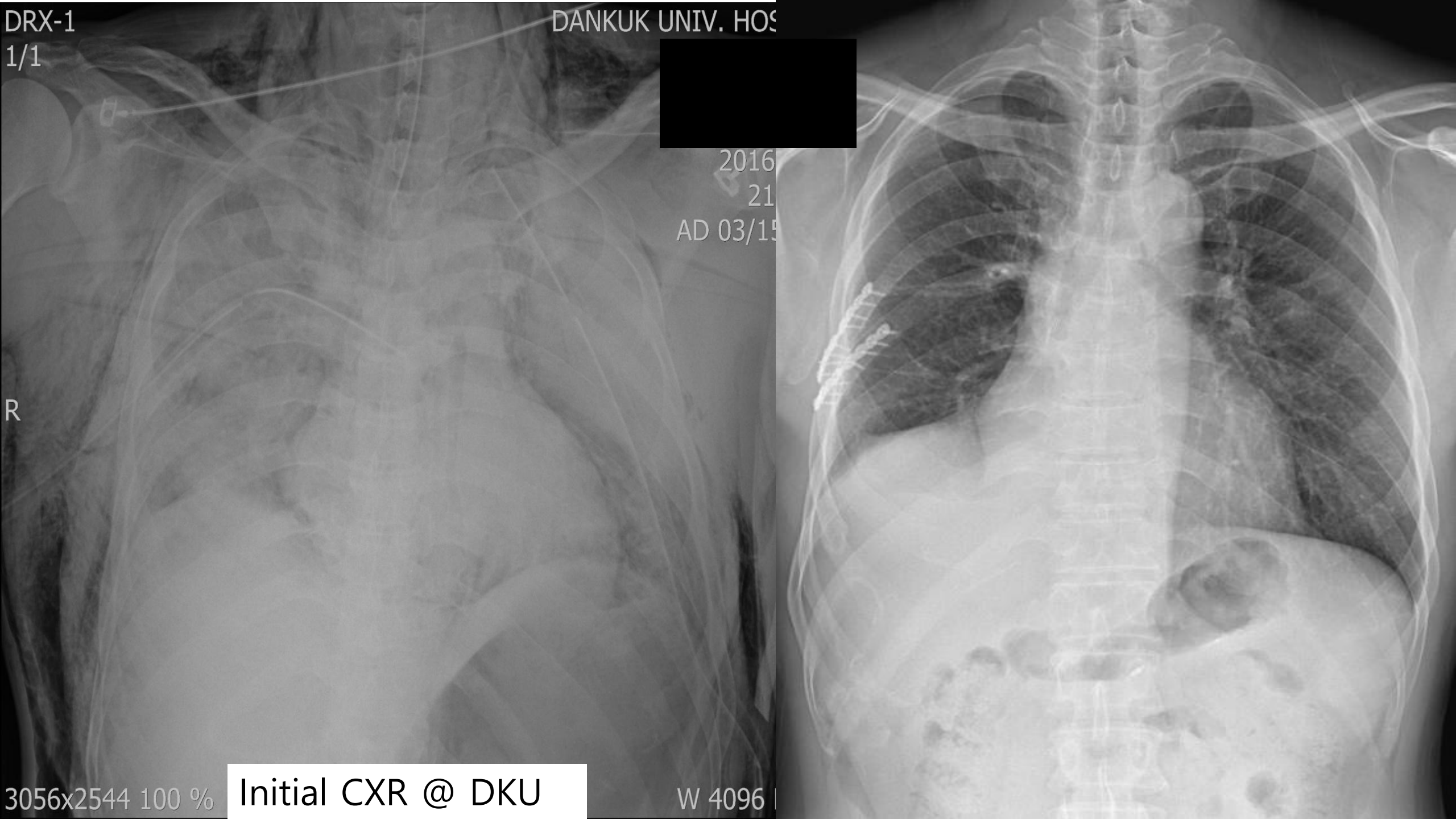

Initial CXR @ DKU

Breathing

- Temporarily releasing the cervical collar with cervical immobilization
- Expose the chest and neck
- Respiratory movement and quality of respiration
    - Observing (cyanosis, symmetrical movement), Palpation and Listening
- Neck vein distention by disturbance of venous return
    - Tension pneumothorax, Cardiac tamponade, Diaphragm rupture etc.


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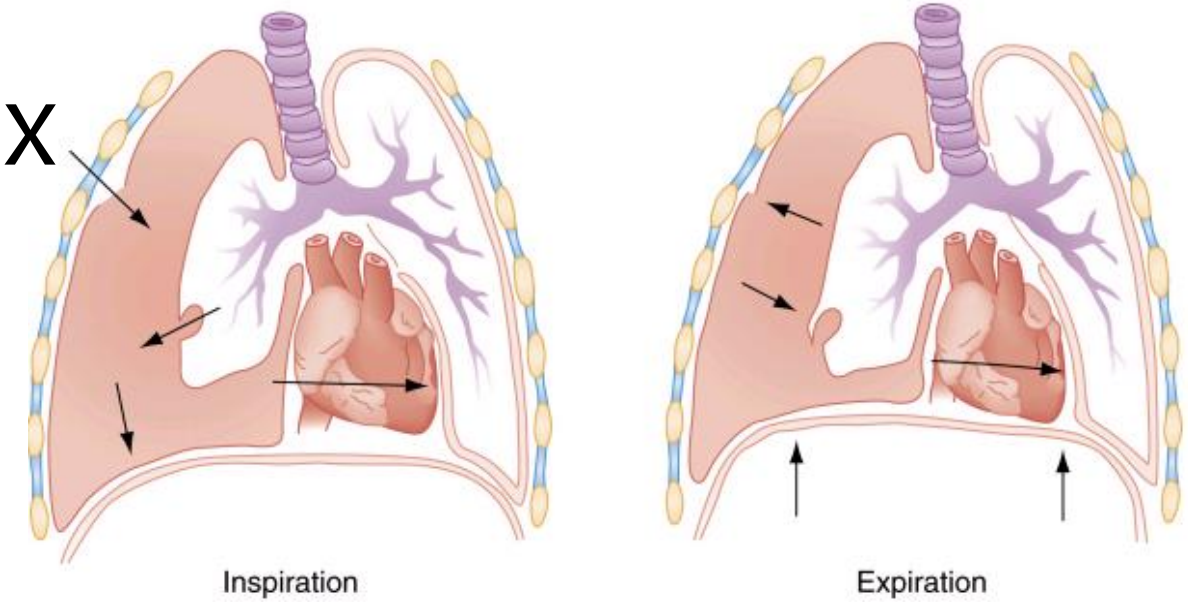
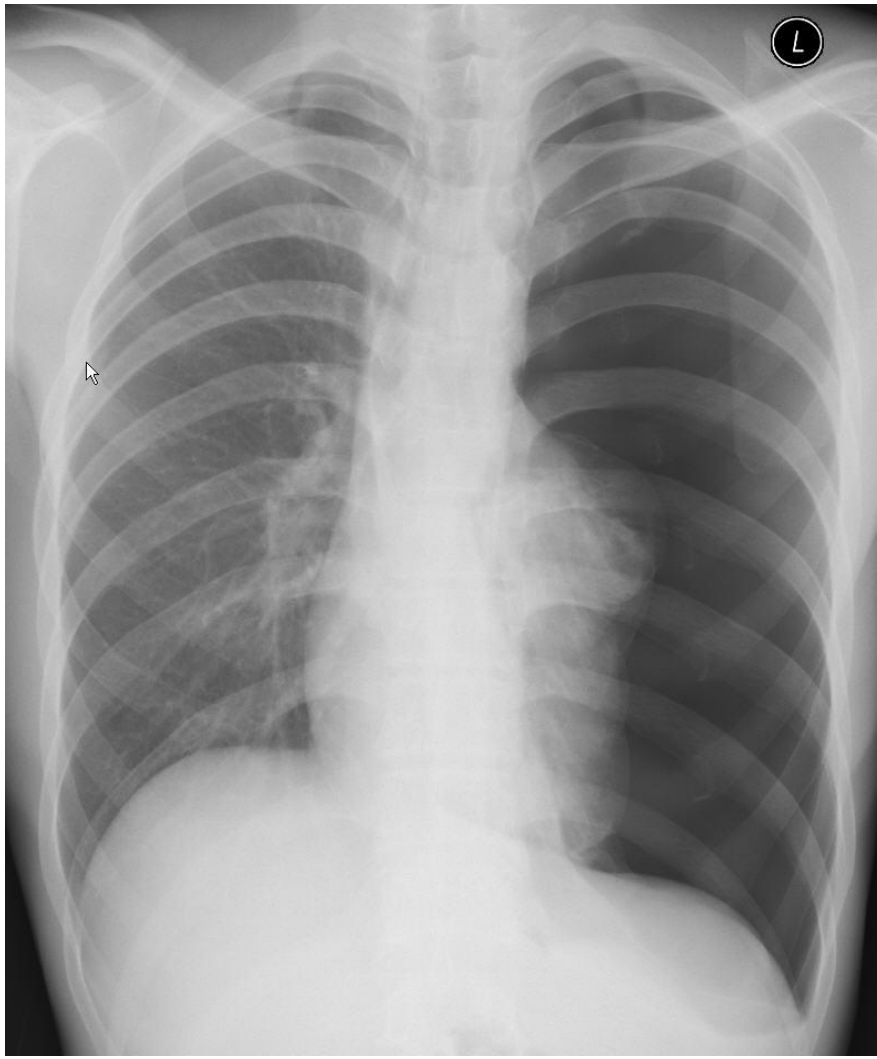
Tension pneumothorax



- Pathophysiology
  - One-way valve
  - Inspiration ➔ Air leak into pleural space ➔ Trapped during exhalation
    ➔ Increase of the pleural pressure ➔ Mediastinal shift
    ➔ Compression of the uninjured lung
    ➔ Kinking and compression: superior/inferior vena cava
  - Obstructive shock due to decreasing the venous return

- Most common cause: Mechanical ventilation with positive-pressure
- Caution: Simple pneumothorax → Tension pneumothorax
- Signs and Symptoms
  - Chest pain
  - Respiratory distress
  - Tachycardia
  - Hypotension
  - Neck vein distention
  - Tracheal deviation away from the side of injury
  - Unilateral absence of breath sounds
  - Elevated hemithorax without respiratory movement



- Similarity in their signs – Cardiac tamponade

  - Differentiation: Hyperresonant sound on percussion

    Absent breath sound, deviated trachea

- Tx: Meedle thoracostomy (Two optimal location)

  Finger thoracostomy

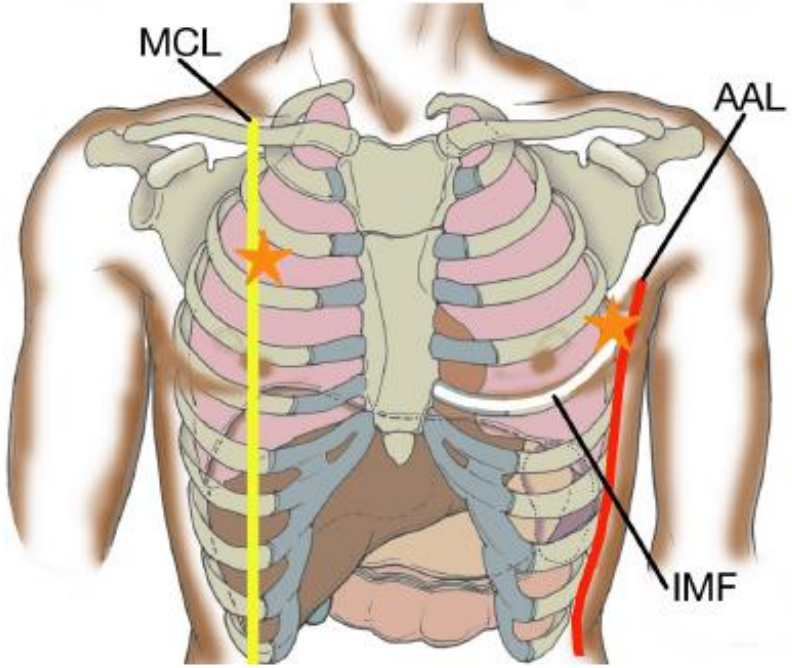
  Definitive treatment: tube thoracostomy

- Limitation of needle decom.

  Variable chest wall thickness

  Kinking of the catheter

■ **Figure 5-11: Locations for Emergent Needle Thoracostomy.**
Two consensus optimal locations for safe and effective needle decompression are indicated by the stars. One is between the anterior (AAL) and mid axillary (MAL) lines at the inframammary fold (IMF) level and the other is in the second intercostal space at the midclavicular line (MCL).



Open pneumothorax

- Normal physiology – Negative pressure of intra-thoracic cavity

  Inspiration: -9 to –12cmH2O, Expiration : -3 to –6cmH2O

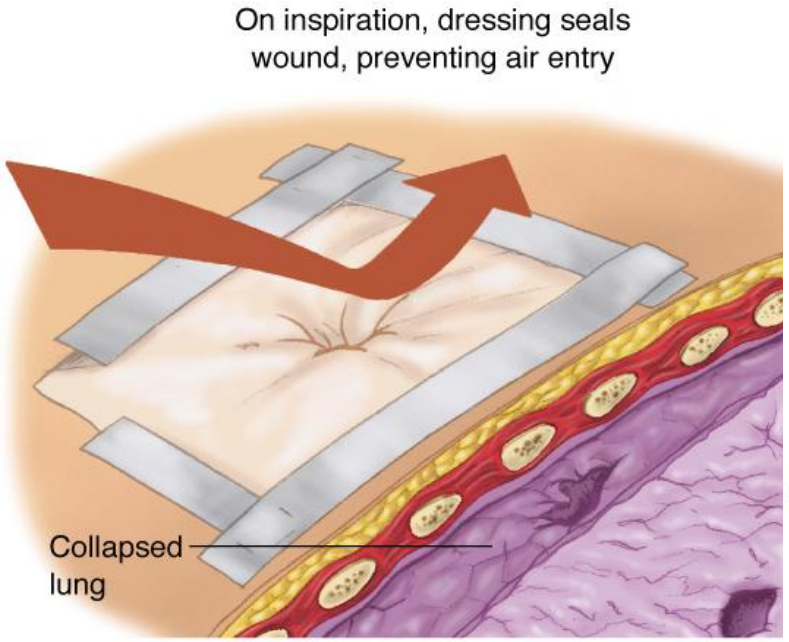
- Defect of chest wall ➔ Equilibration ➔ Impairment of effective ventilation
- Tx: Promptly coverage of the defect

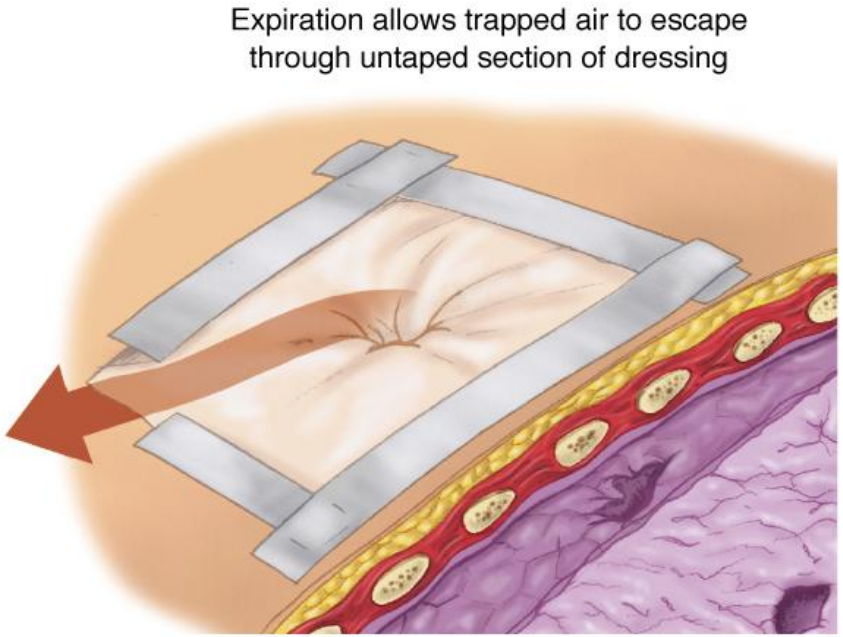
  with sterile occlusive dressing (3 sides)

  Closed thoracostomy (remote from the wound)

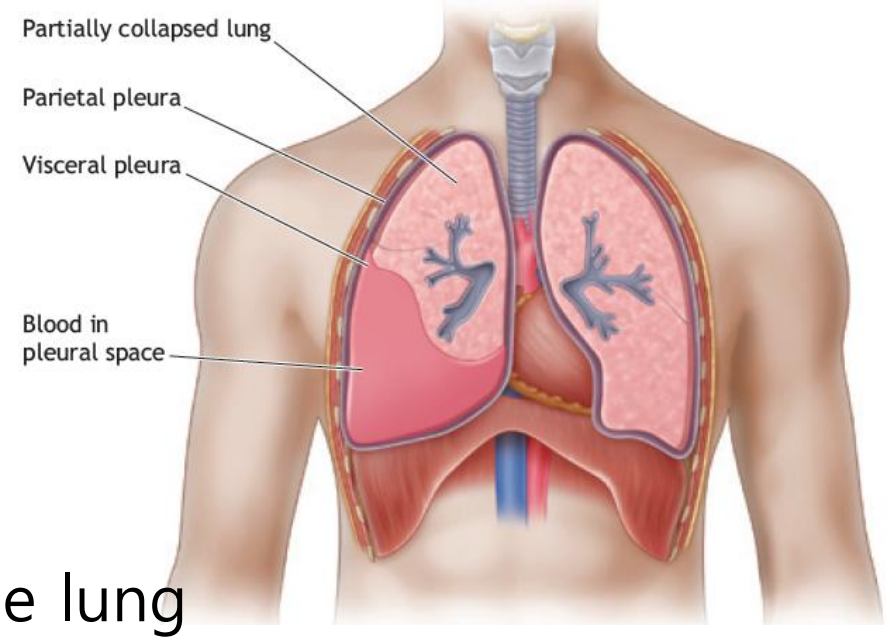
  Definitive surgical closure of defect

Three side occlusive dressing





Massive hemothorax



- Pathophysiology

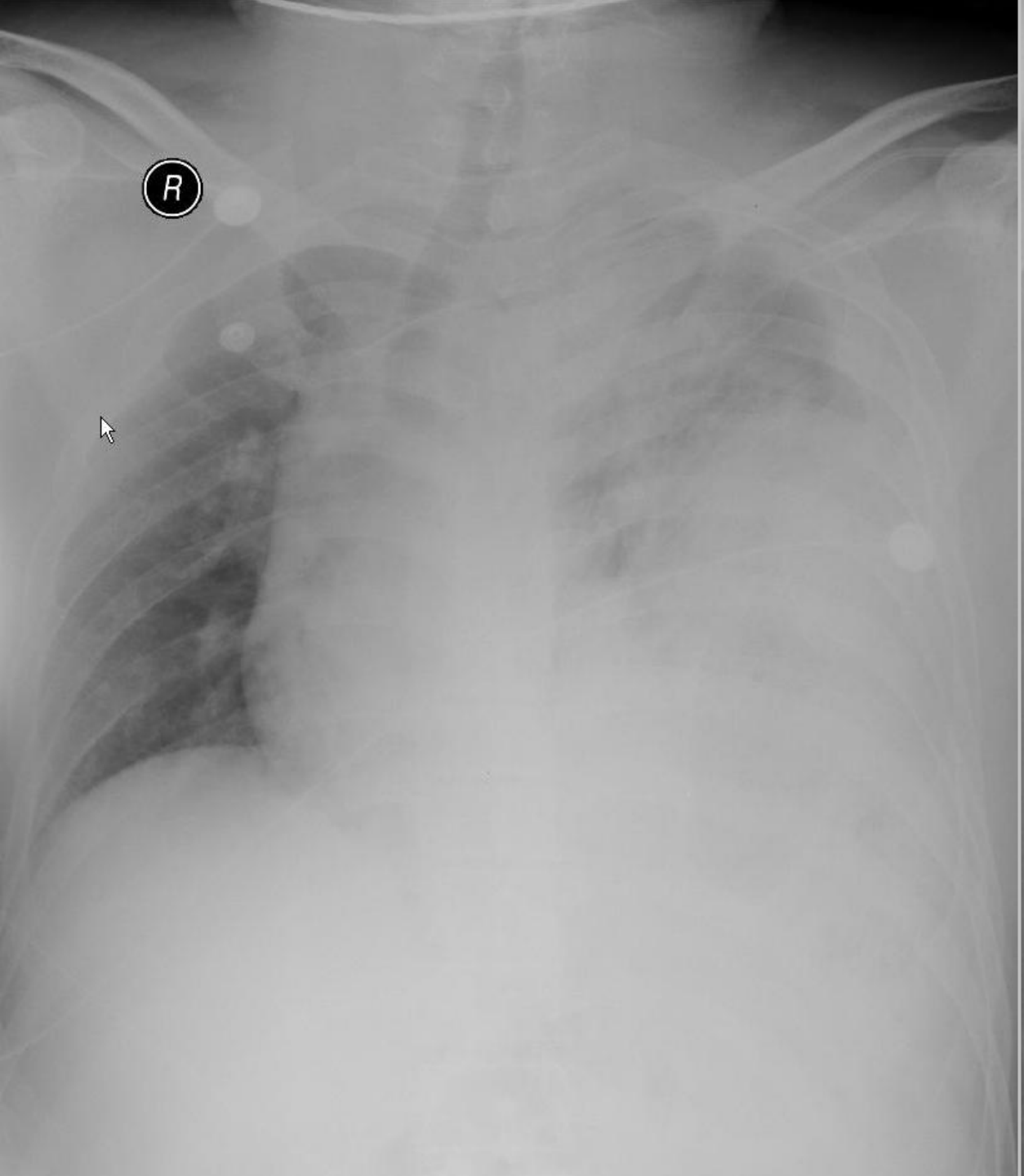
  - Accumulation of blood ➔ Compressing the lung

    ➔ Inadequate ventilation, Hypotension and Shock

- Differentiation: Hyporesonance(dullness) on injury side (hemothorax)

  No elevation of the affected hemithorax during respiration

- Association with breathing and circulation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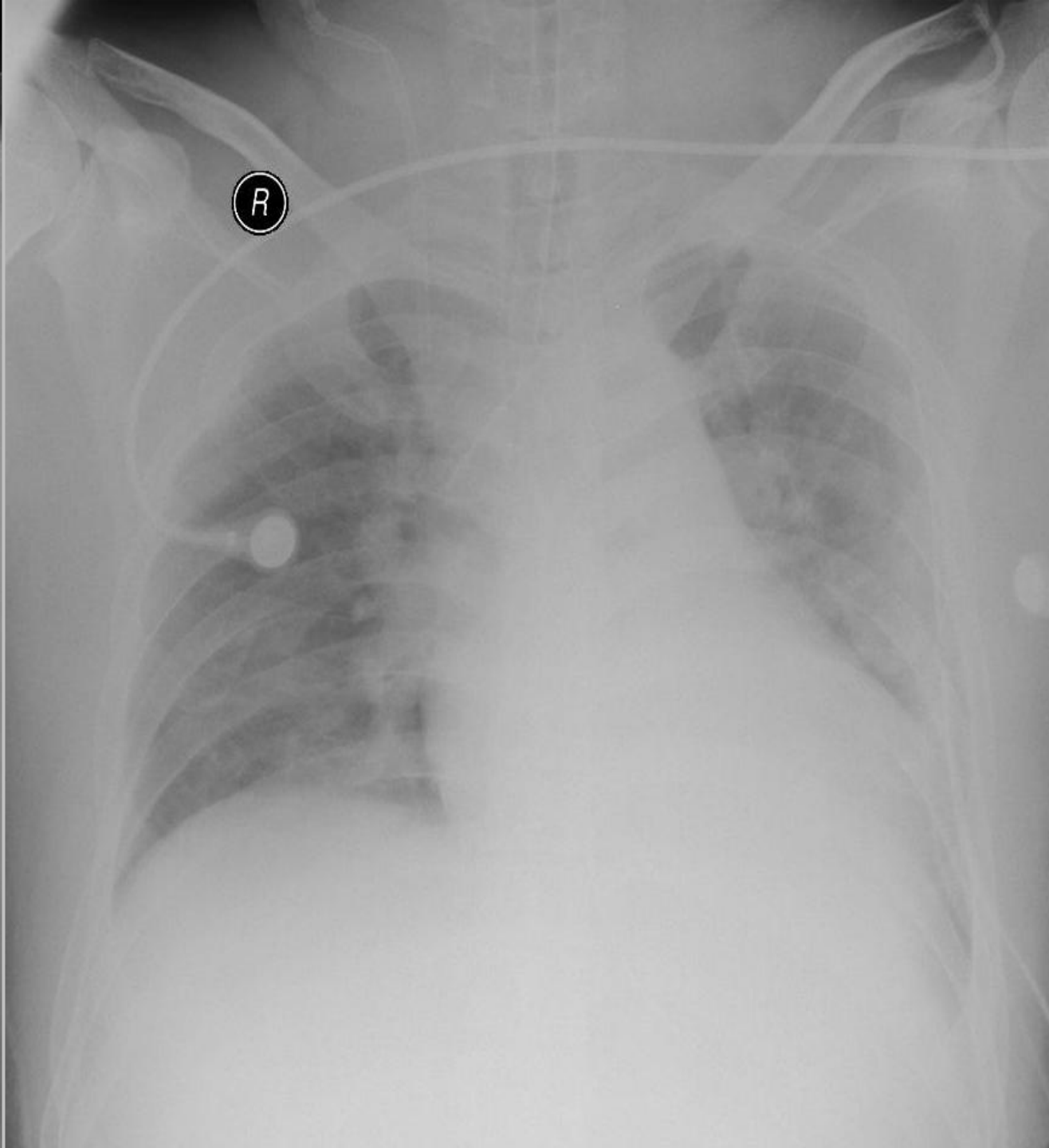
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- Accumulation of more than 1500mL of blood, 1/3 or more of chest cavity
- Most commonly cause: Penetrating injury (vascular injury), from Blunt injury
- Rarely neck vein distention due to severe hypovolemia
- Tx: Restoration of blood volume using large IV lines, Closed thoracostomy
- Indication of thoracotomy (operation)
    - Initial evacuation: more than 1500mL
    - Continuing blood loss (200mL/hr for 2-4 hours),
    - Persistent need for blood transfusion, Increased hemothorax on Chest X-ray
    - Penetrating anterior chest wound(medial) or posterior wound(scapula)

        ➔ Potential damage to Great vessels, Pulmonary hilar structures, and Heart injury

Potentially life-threatening injuries - THORAX

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Secondary survey

- Further, In-depth physical examination
- Radiologic exam (CT)
- Arterial Blood Gas Analysis (ABGA)
- ECG monitoring
- Etc …….

Objectives

OBJECTIVES

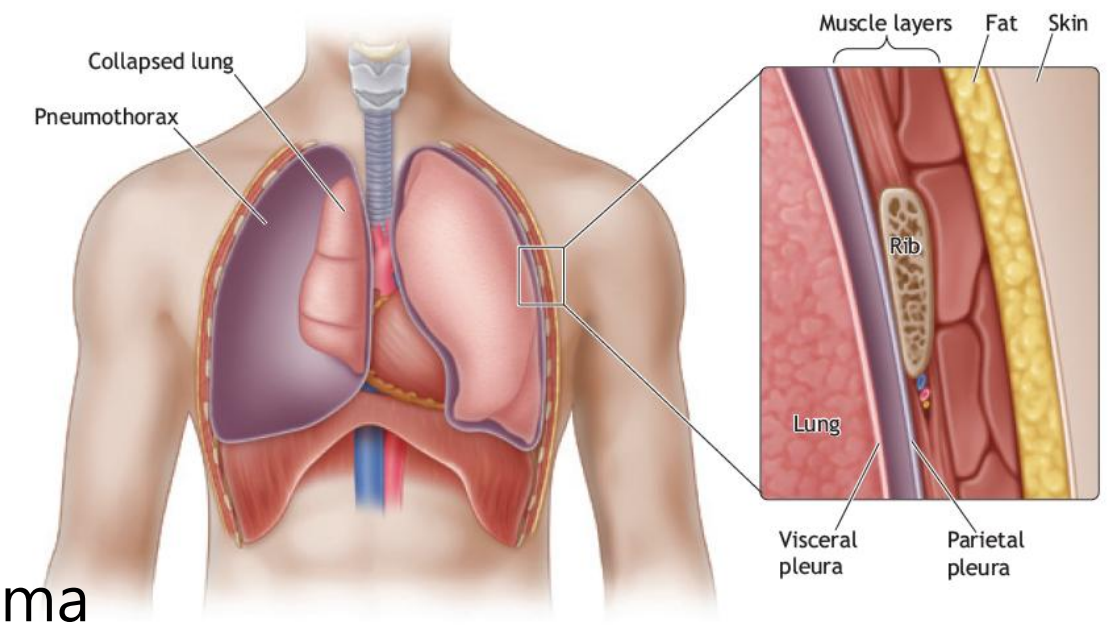
After reading this chapter and comprehending the knowledge components of the ATLS provider course, you will be able to:

1. Identify and describe treatment of the following life-threatening injuries during the primary survey: airway obstruction, tracheobronchial tree injury, tension pneumothorax, open pneumothorax, massive hemothorax, and cardiac tamponade.

2. Identify and describe treatment of the following potentially life-threatening injuries during the secondary survey: simple pneumothorax, hemothorax, flail chest, pulmonary contusion, blunt cardiac injury, traumatic aortic disruption, traumatic diaphragmatic injury, and blunt esophageal rupture.

3. Describe the significance and treatment of subcutaneous emphysema, thoracic crush injuries, and sternal, rib, and clavicular fractures.

Simple pneumothorax



- 10% to 30% in blunt chest trauma
- Almost 100% with penetrating chest trauma
- Air in the pleural space

  ➔ disruption between visceral and parietal pleura ➔ allow the lung collapse

- May occur in the absence of rib fractures from:

  - Paper-bag effect: A sudden increase in intrathoracic pressure

    (🡐 the chest wall is compressed against a closed glottis)

- Ventilation/Perfusion mismatch
- Affected side: decreased breathing sound, hyperresonance on percussion
- Dx: Chest X-ray. Extended FAST (E-FAST), Chest CT
- Tx: Closed thoracostomy
- General anesthesia or positive-pressure mechanical ventilation without C-tube
    - Simple pneumothorax ➔ Unexpected tension pneumothorax
- In case of air transportation (helicopter)
    - Pneumothorax should undergo closed thoracostomy due to altitude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Hemothorax

- Cause

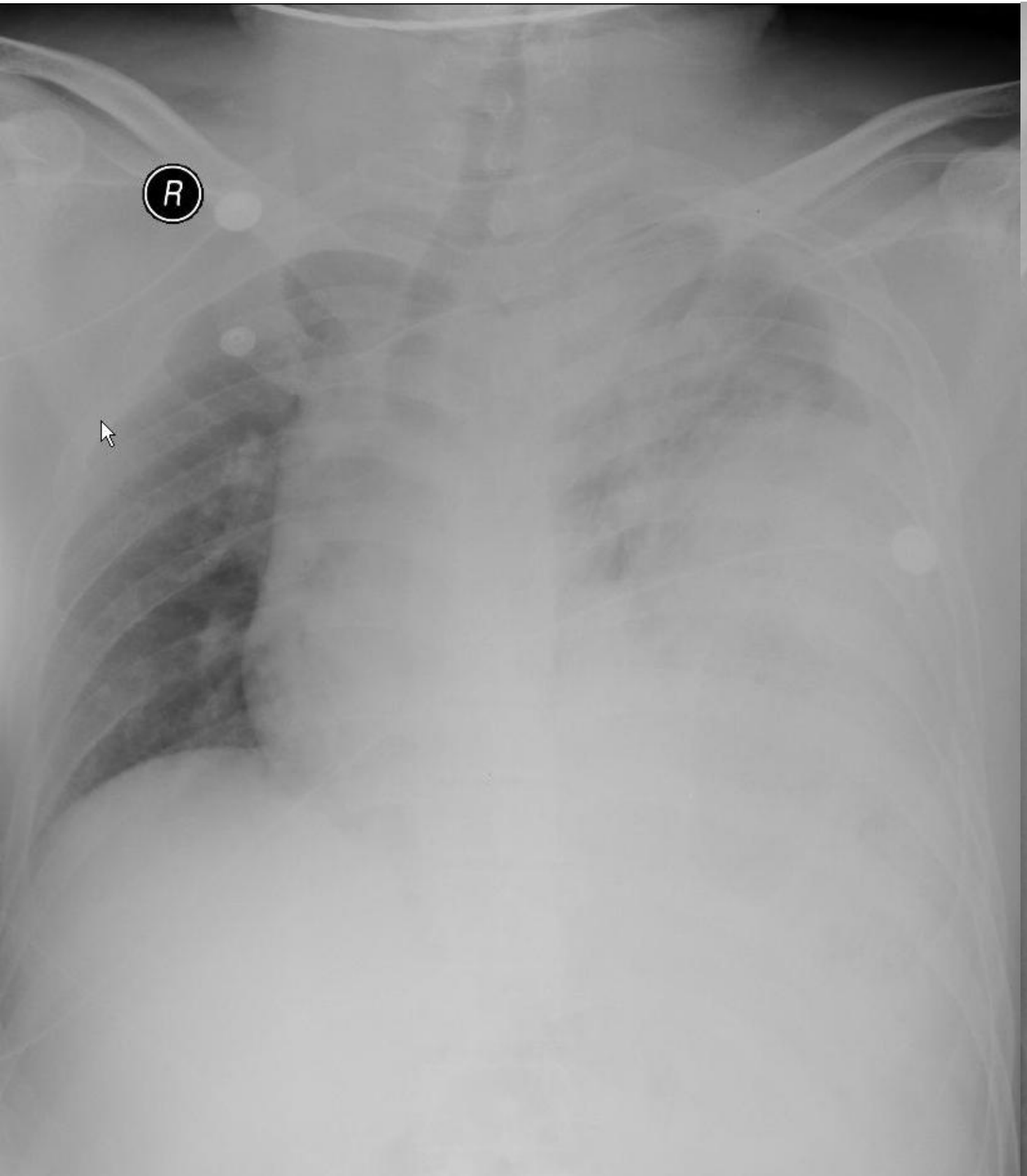
  : lung laceration, intercostal vessel or internal mammary artery injury

    thoracic spine fracture, rib fracture, diaphragm injury etc.

- Tx: Closed thoracostomy (for reducing the risk of a clotted hemothorax)

    If patient`s hemodynamic status is unstable, clotted hemothorax

    ➔ decision for operation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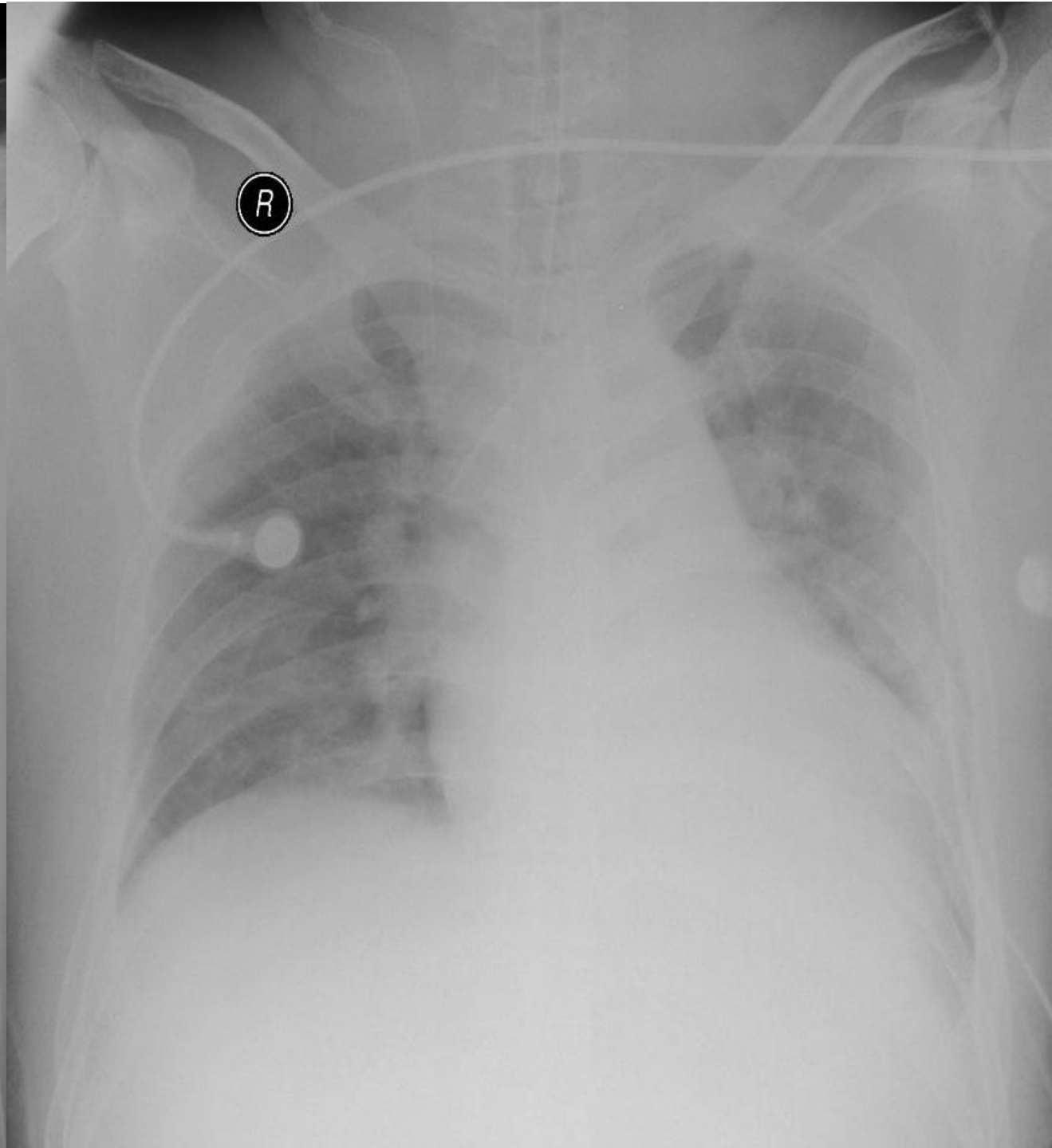
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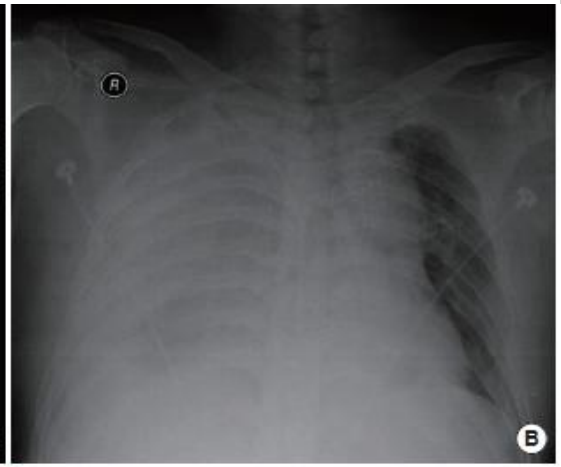
Delayed massive hemothorax requiring surgery after blunt thoracic trauma over a 5-year period: complicating rib fracture with sharp edge associated with diaphragm injury

Sung Wook Chang, Kyoung Min Ryu, Jae-Wook Ryu



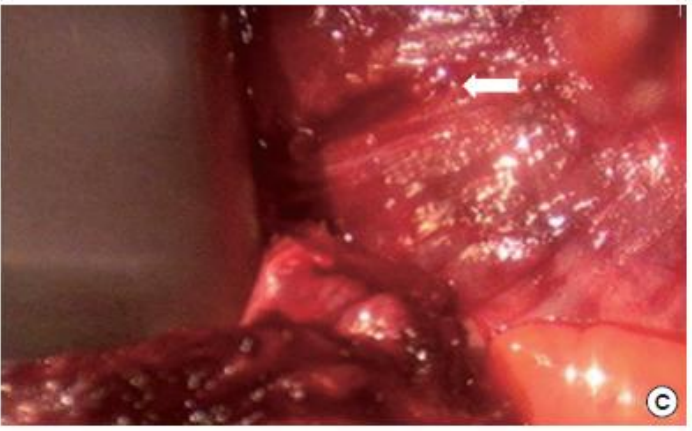
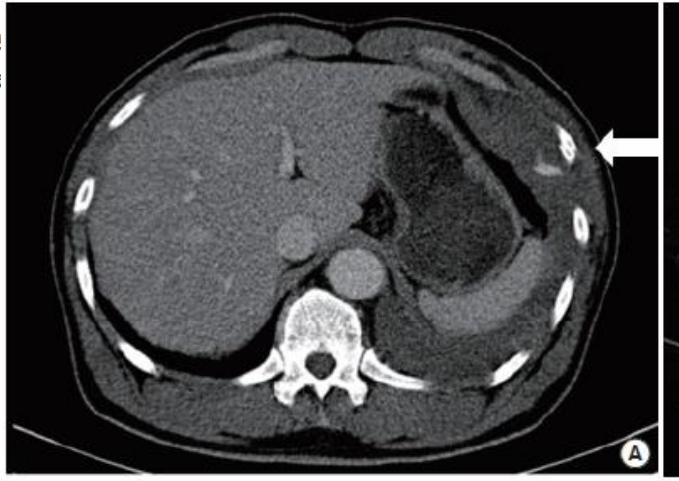
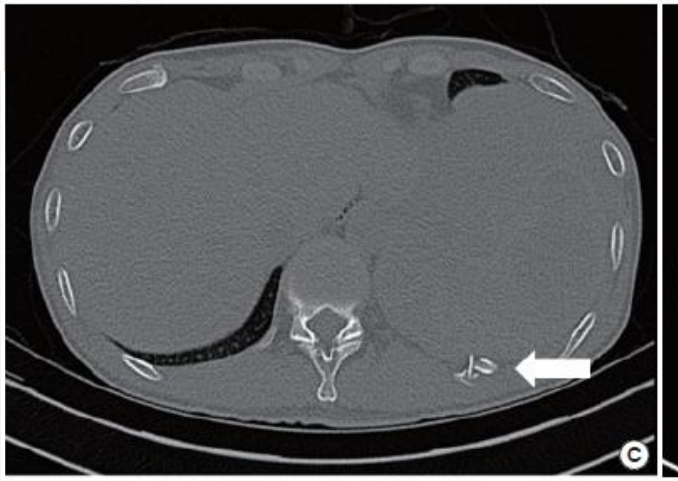


Fig. 2. Patient 5. (A) Computed tomography showing an aortic dissection without right hemothorax. (B) Follow-up chest radiograph after thoracic endovascular aortic repair showing massive right hemothorax. (C) Intraoperative photograph showing active bleeding on the diaphragm due to superficial injury (arrow).





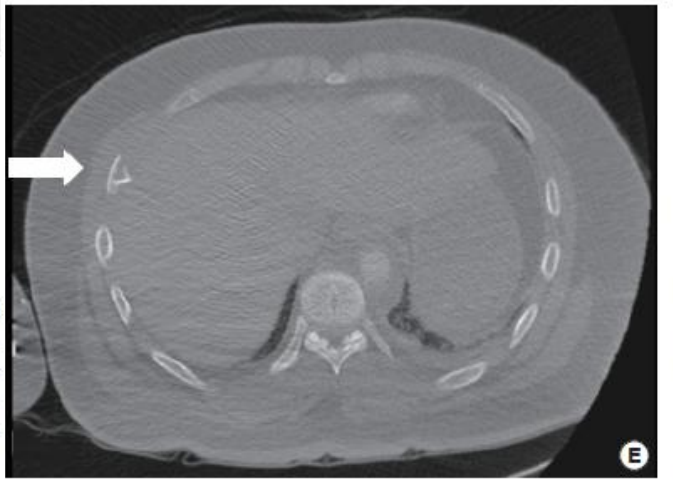
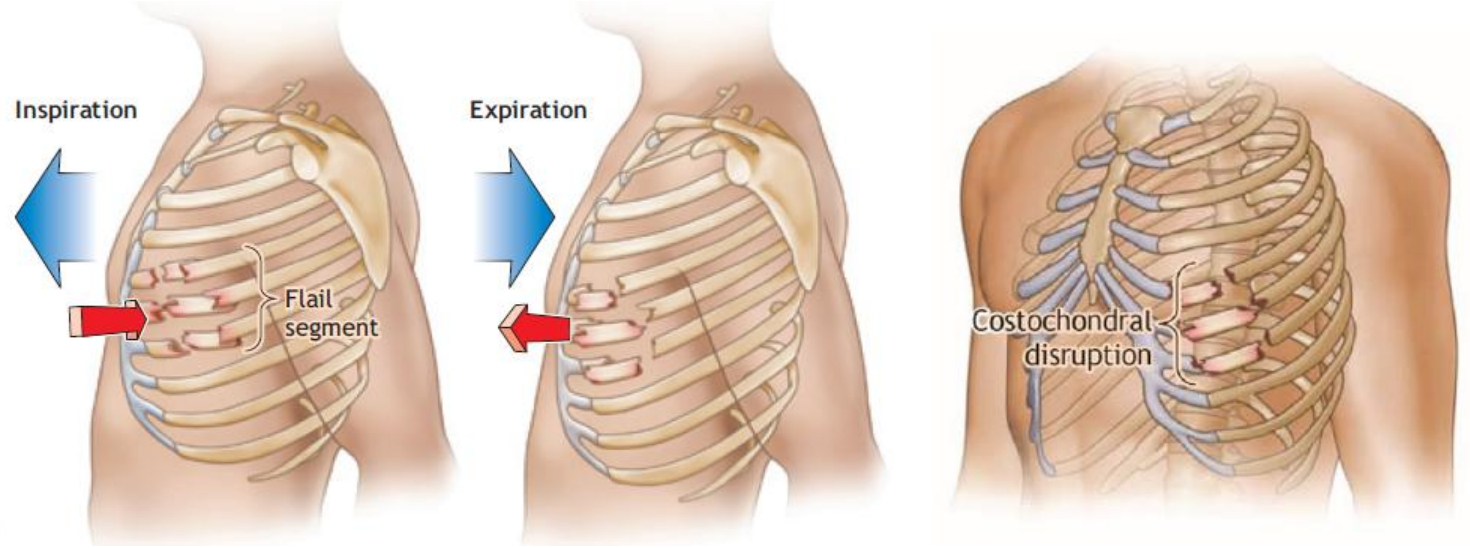
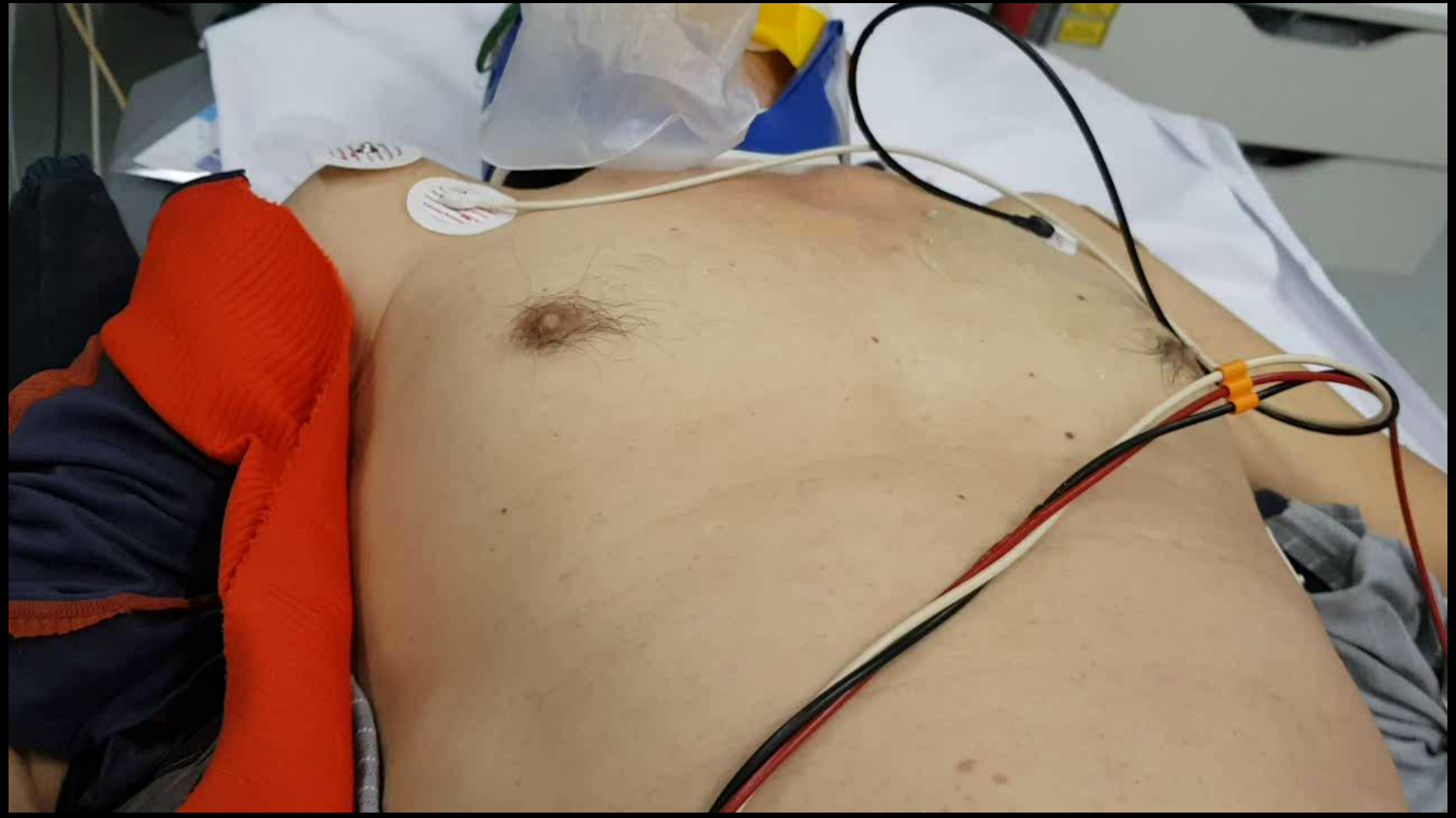


Fig. 1. Chest computed tomography (CT) after blunt thoracic trauma showing a fractured rib with a sharp edge (arrows). (A) Patient 1. Delayed hemothorax and extravasation seen 93 hours after the initial CT. (B) Patient 2. CT showing only a fractured rib with no hemothorax 7 hours later. (C) Patient 3. Delayed hemothorax seen 66 hours later. (D) Patient 4. Delayed hemothorax and extravasation seen 63 hours after the initial CT. (E) Patient 5. CT showing left hemothorax and periaortic hematoma 2 hours later.

Flail chest



- A radiographic flail segment
  - Two or more adjacent ribs fracture in two or more places
- Clinical flail chest
  - Disruption of normal chest wall movement ➔ Paradoxical movement
  - Asymmetrical and uncoordinated movement of thorax
- Commonly associated with lung contusion ➔ Hypoxia
- Observation and palpation of motion/crepitus/cartilage fracture

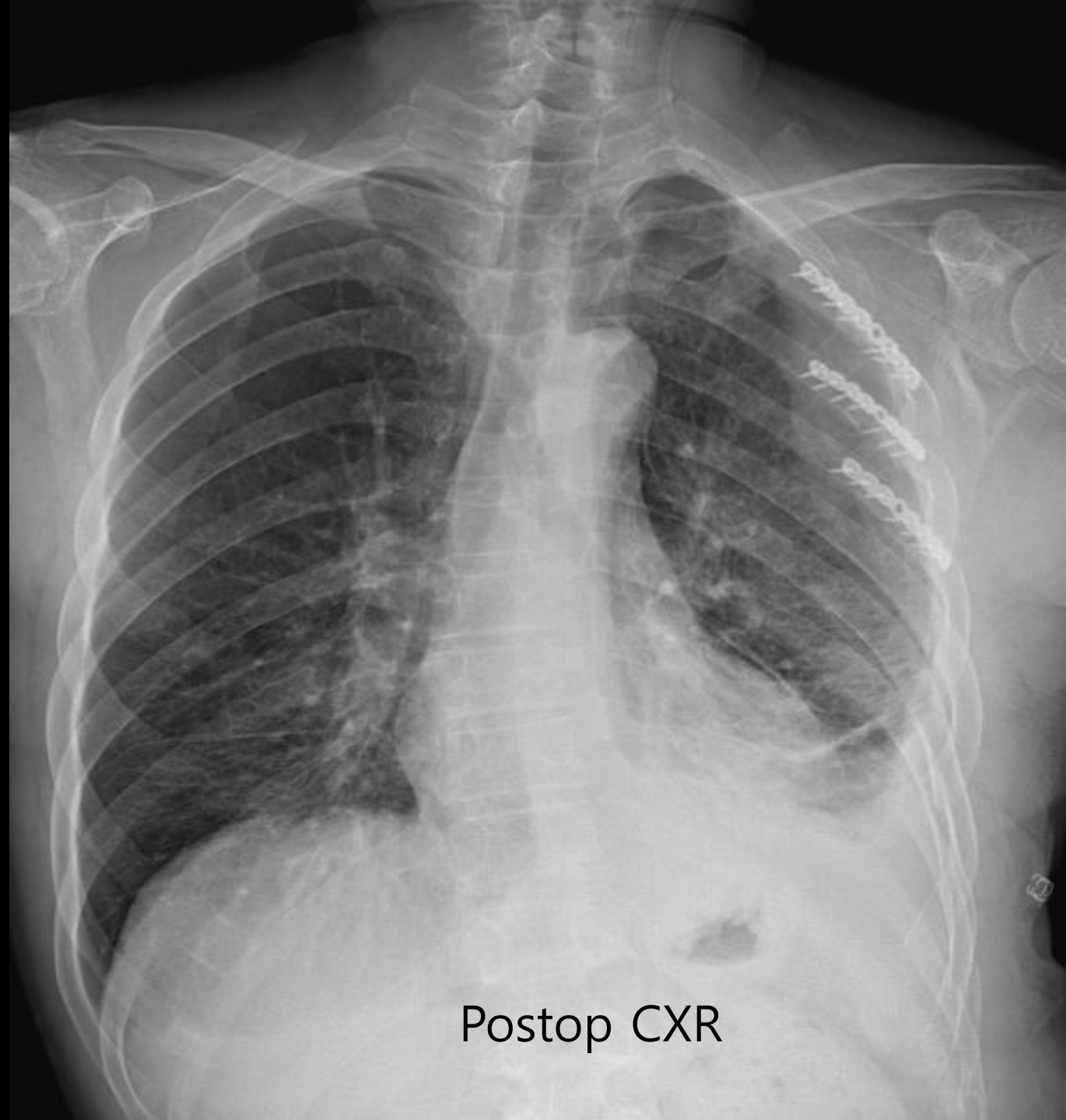


- Tx: Adequate ventilation, Administration of humidified oxygen, Pain control

  Fluid resuscitation (avoid the volume overload). Prn) Operation

Flail chest

Preop CXR



Postop CXR

Pulmonary contusion – Intrapulmonary hemorrhage

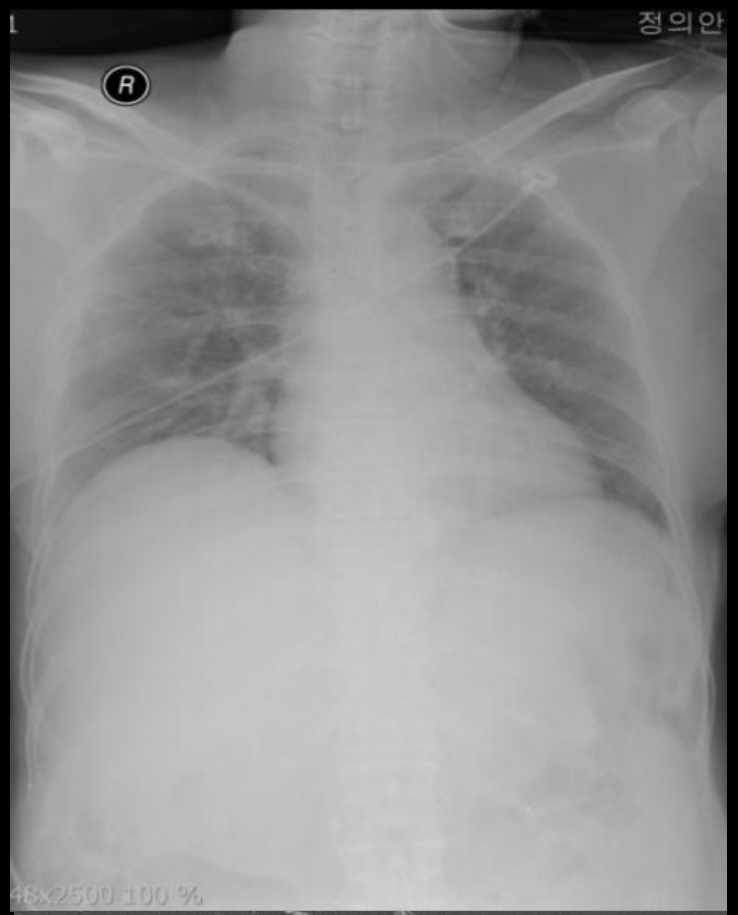
Deceleration injury, Compression

- Young patient: occur without rib fracture/flail chest
- In adults: most commonly seen with concomitant rib fracture
- In room air, significant hypoxia ((i.e., PaO_2 <65mm Hg or SaO_2 <90%)

  ➔ Intubation and ventilation within the first hour after injury
- Underlying chronic obstructive disease, renal failure ➔ Intubation need ↑
- Monitoring: Pulse oximeter, ABGA, ECG
- 24-72 hours later ➔ ARDS

Sx: Hemoptysis

Suspicion ➔ CT scan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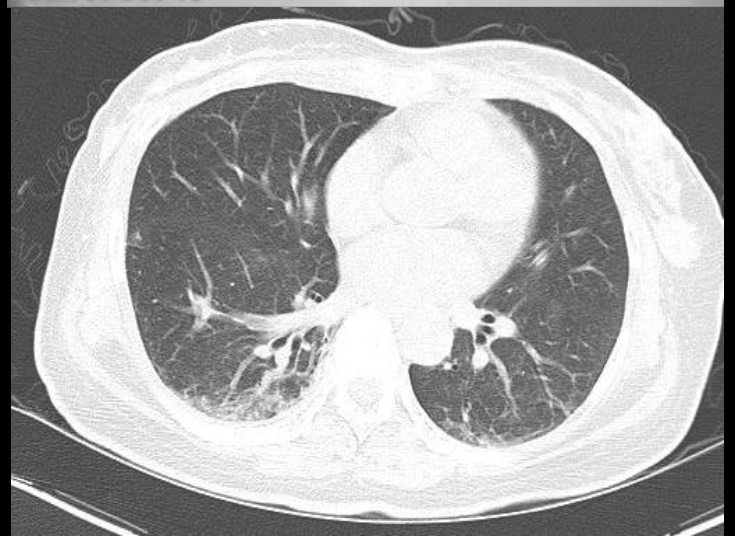
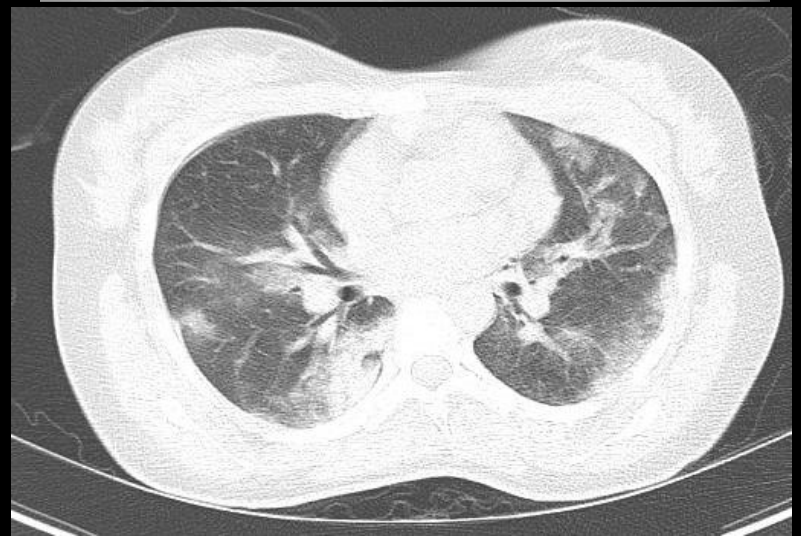
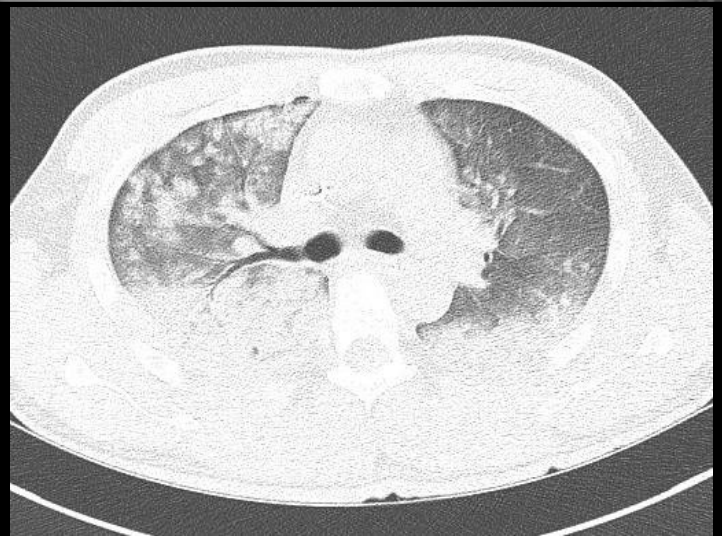




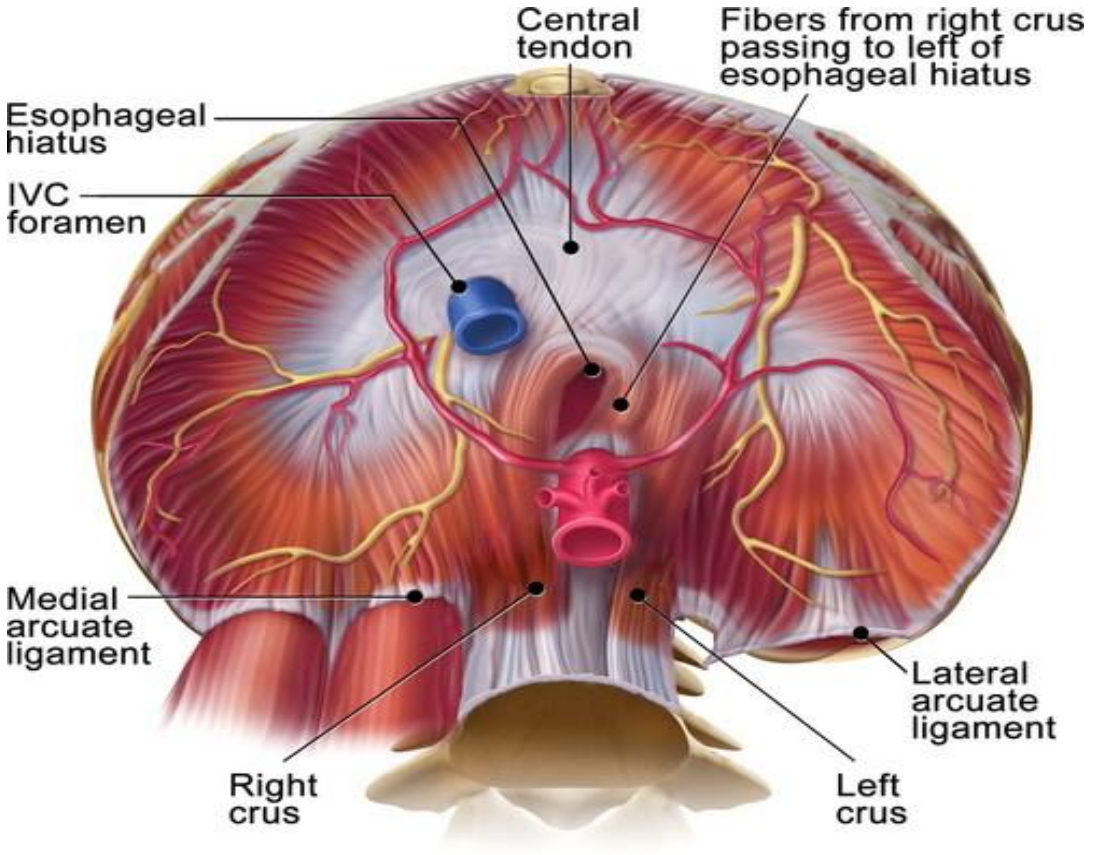


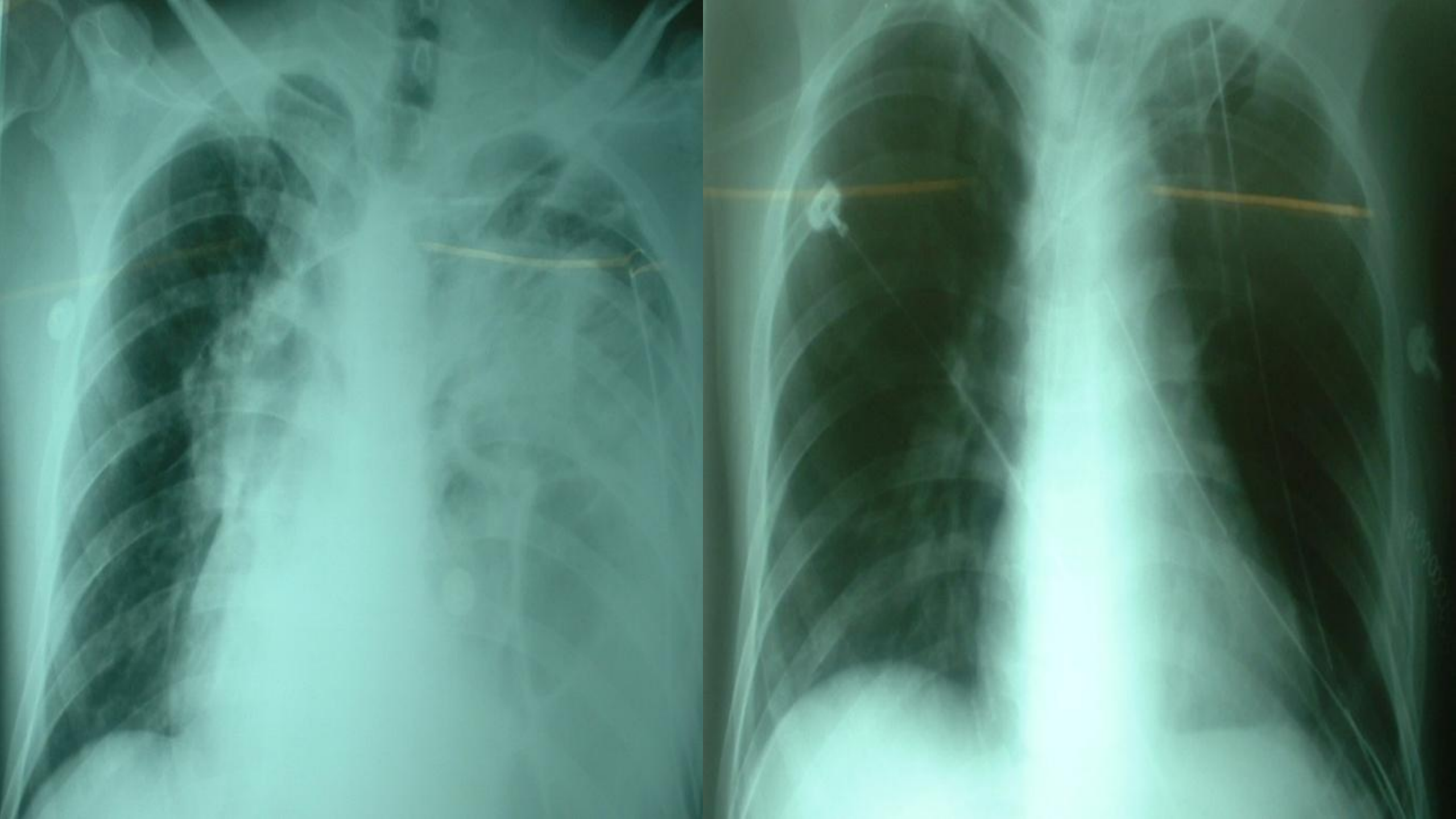
Traumatic diaphragm injury

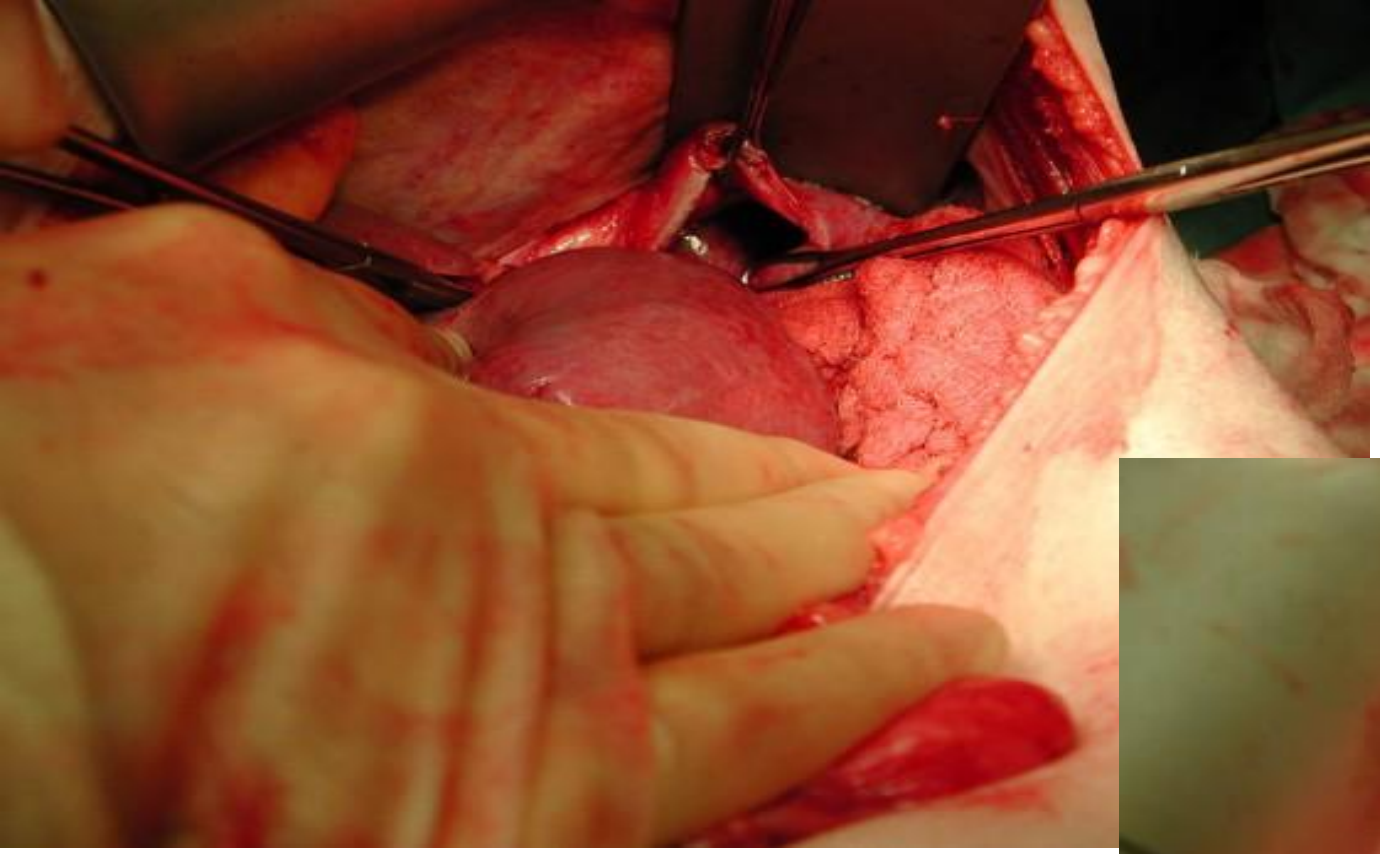
- More commonly diagnosed on the left side (Right: liver)
- Left hemithorax: appearance of bowel, stomach, nasogastric tube …
- Blunt trauma: large tear and herniation of organ
- Penetrating trauma: small and even years, to develop into hernia
- Frequently missed: diaphragm elevation, loculated hemopneumothorax…
- Pathophysiology: Increased intra-abdominal pressure

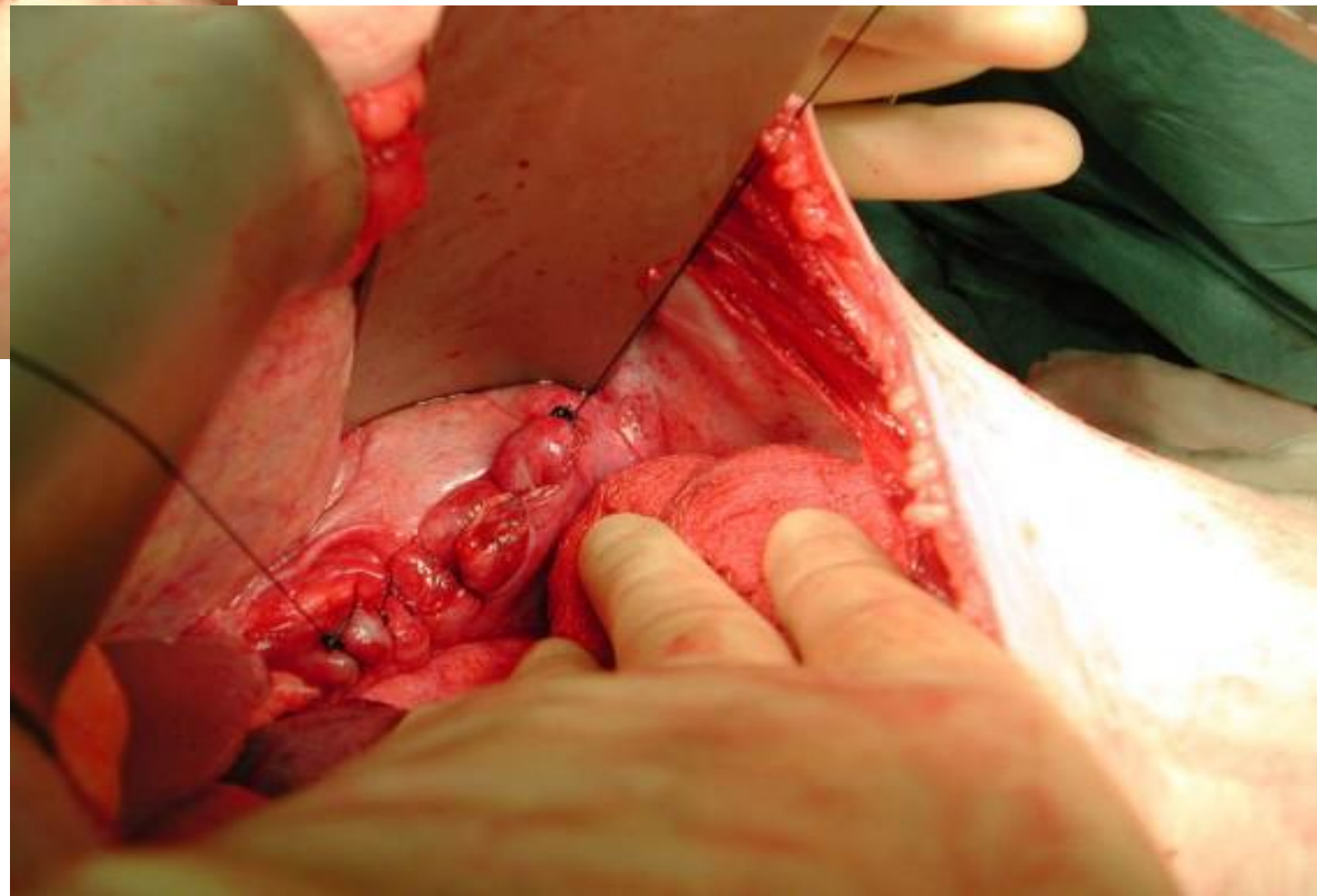
  ➔ intra-abdominal organs to enter the thoracic cavity

- Rupture ➔ intra-abdominal organs to enter the thoracic cavity:
  - Compression of the lung with reduced ventilation, Decreased venous return
  - Decreased cardiac output, Shock
  - Bowel obstruction and strangulation
  - Restriction of lung expansion
  - Hypoventilation, Hypoxia
  - Mediastinal shift
- Dx: CT scan, Thoracoscopy/Laparoscopy
- Tx: Surgical repair







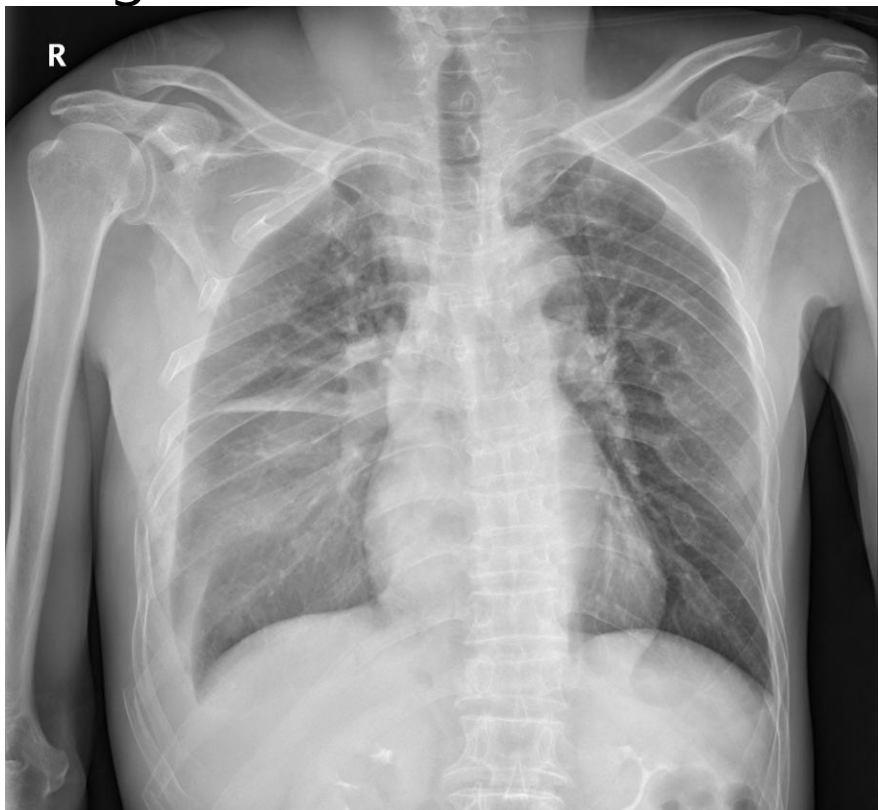


Blunt esophageal rupture

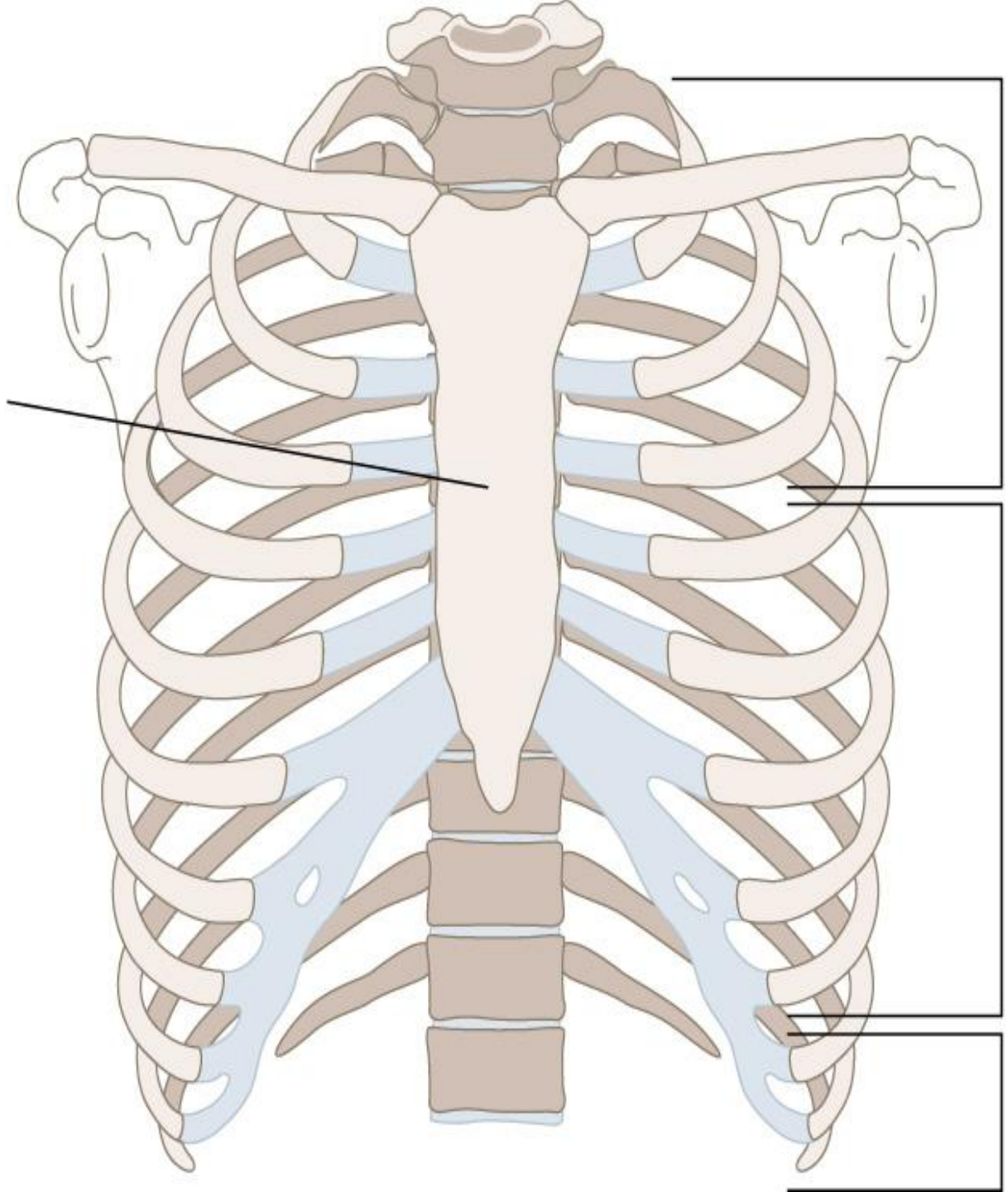
- Esophageal trauma: most commonly from penetrating injury
- More common in the neck than within the thorax due to bony protection
- Forceful ejection of gastric contents ➔ tear ➔ leakage into mediastinum
- Result in mediastinitis (mediastinum), empyema (pleural space)
- Suspicion: postemetic chest pain, mediastinal air, severe blow to epigastrium…
- Dx: Esophagogram, endoscopy, CT
- Tx: Drainage of the pleural space and repair

Rib fracture

- Most often caused by blunt trauma: bowing effect with midshaft fracture
- Respiratory restriction as a result of pain and splinting
- Intercostal vessel injury
- Associated complications
  - First and second ribs are injured by severe trauma
  - Rupture of the aorta
  - Tracheobronchial tree injury
  - Vascular injury



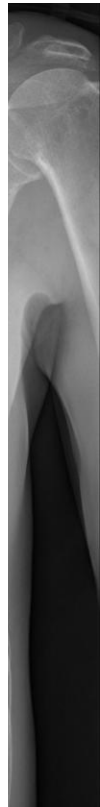
Great force is required for sternal fractures.



Ribs 1–3 are well protected by shoulder bones and muscles.

Ribs 4–9 are most frequently fractured.

Ribs 10–12 are relatively mobile and fracture less frequently.



Sternum fracture

- About 20% ➔ Cardiac contusion
- Associated injuries cause morbidity and mortality

Pulmonary and myocardial contusion

Flail chest

Vascular disruption of thoracic vessels

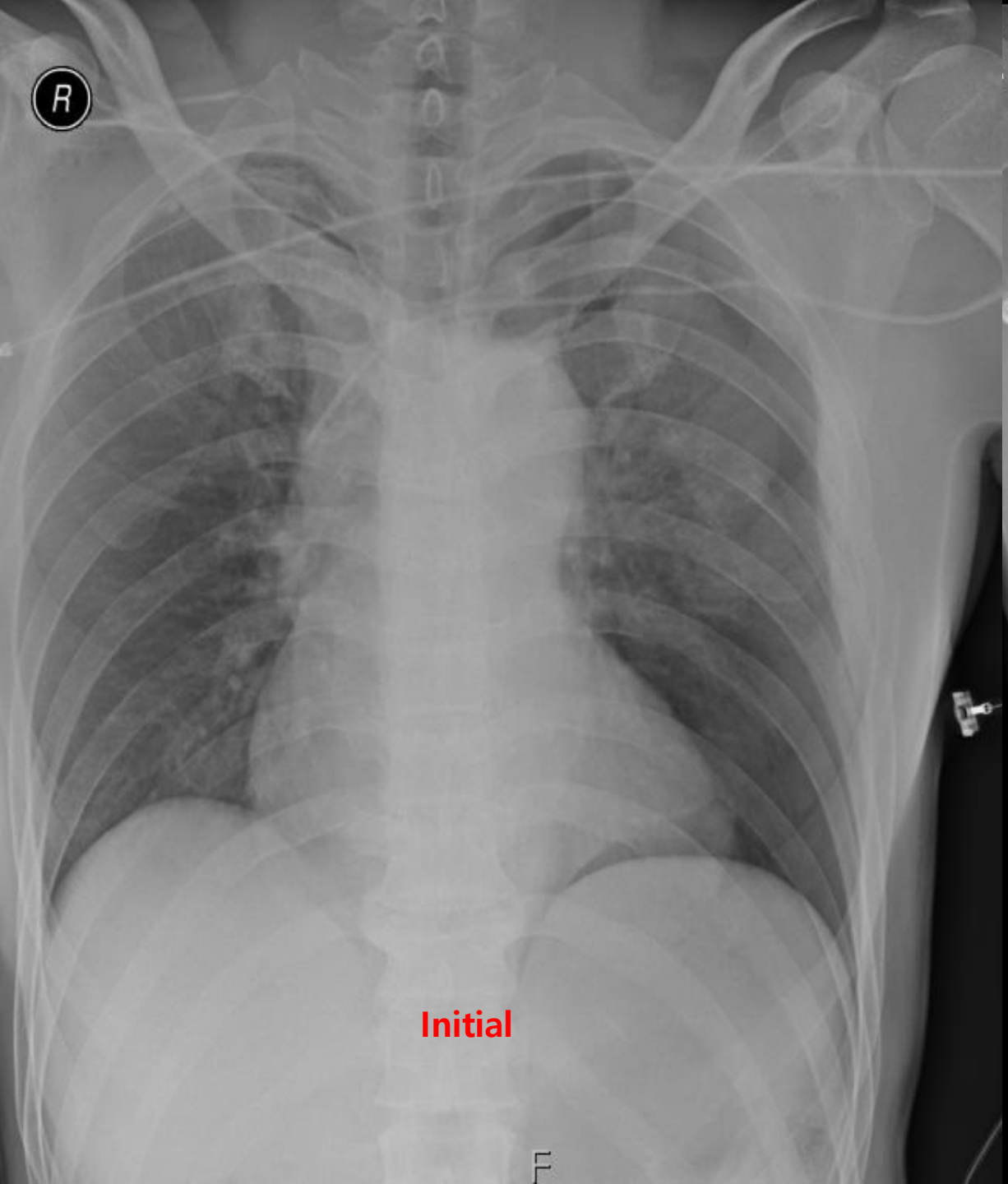
Intra-abdominal injuries

Head injuries

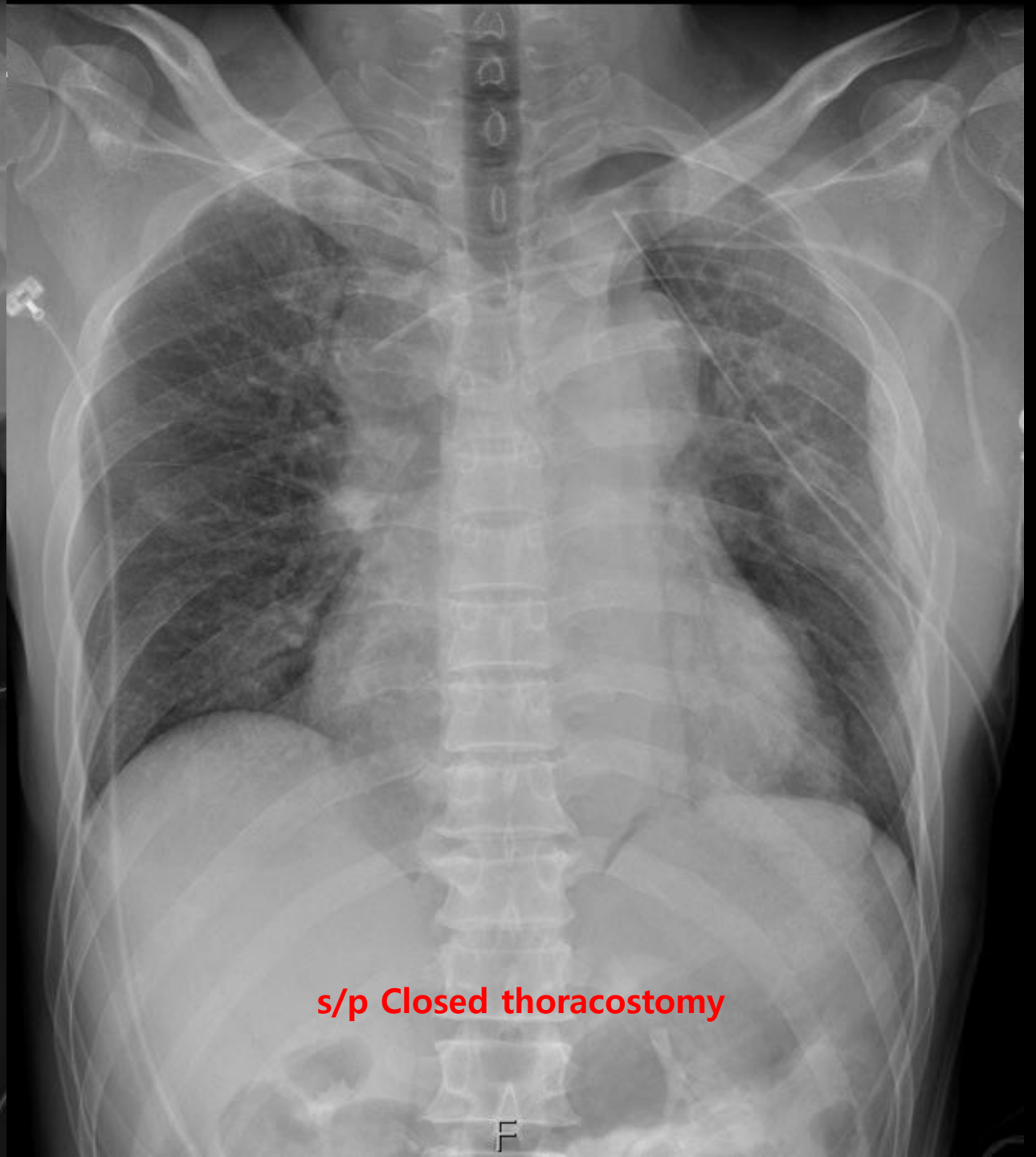
Seriously displaced sternal fractures ➔ produce a flail chest.

Case

- M/45
- In car TA (Driver), Seat belt(-)
- Rt. Leg and ant. Chest pain



Initial



s/p Closed thoracostomy

Progression

- 23:20 환자도착
- 23:40 V/S 92/43-120-36
- 00:00 s/p C-thoracostomy, 89/45 mmHg-128/min-32/min, PRC 2P T/F
- 01:35 From CT room to Resuscitation room 67/32mmHg-100/min-28/min

- Angiography and embolization HOLD
- Em-op

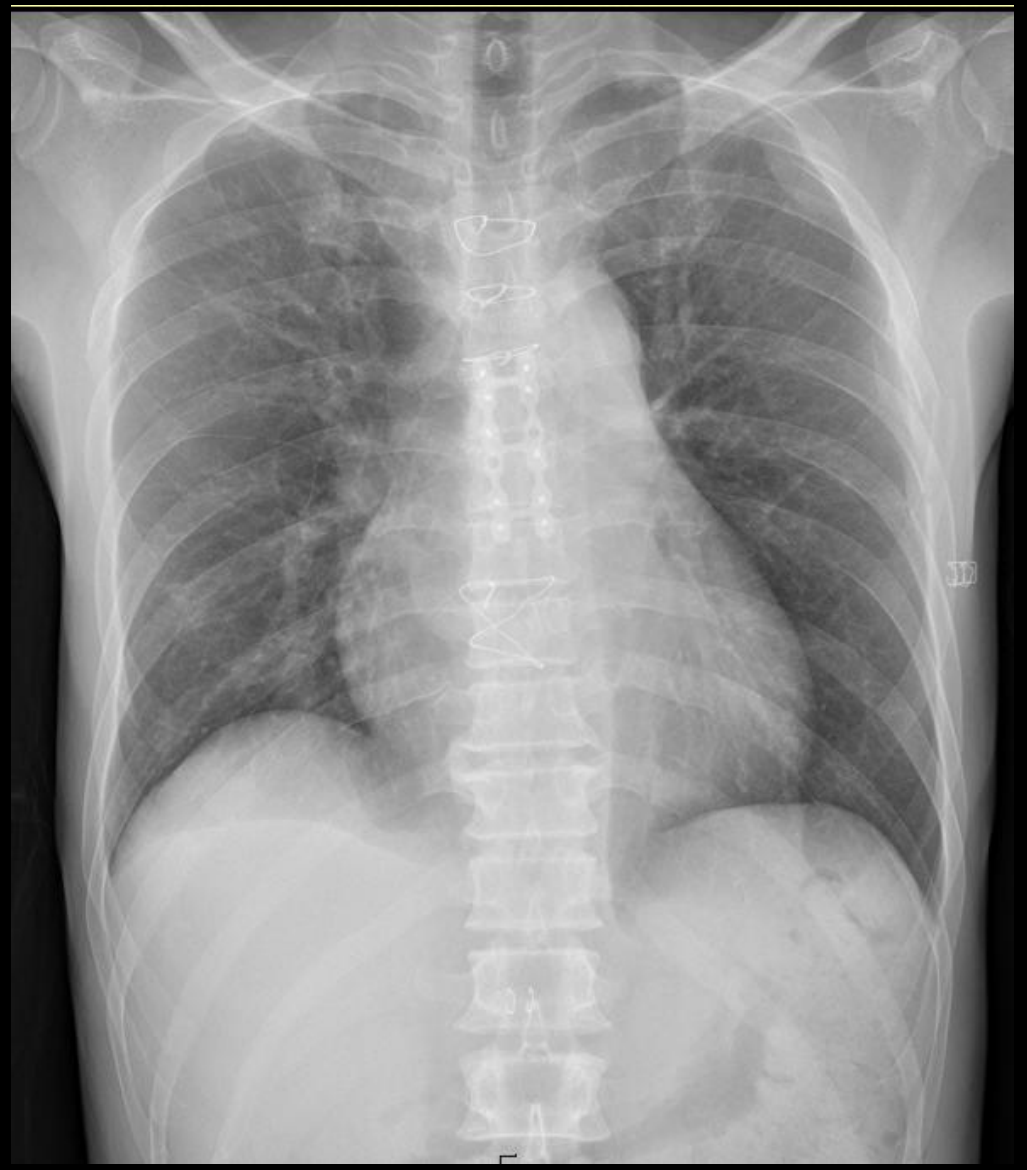
OP finding

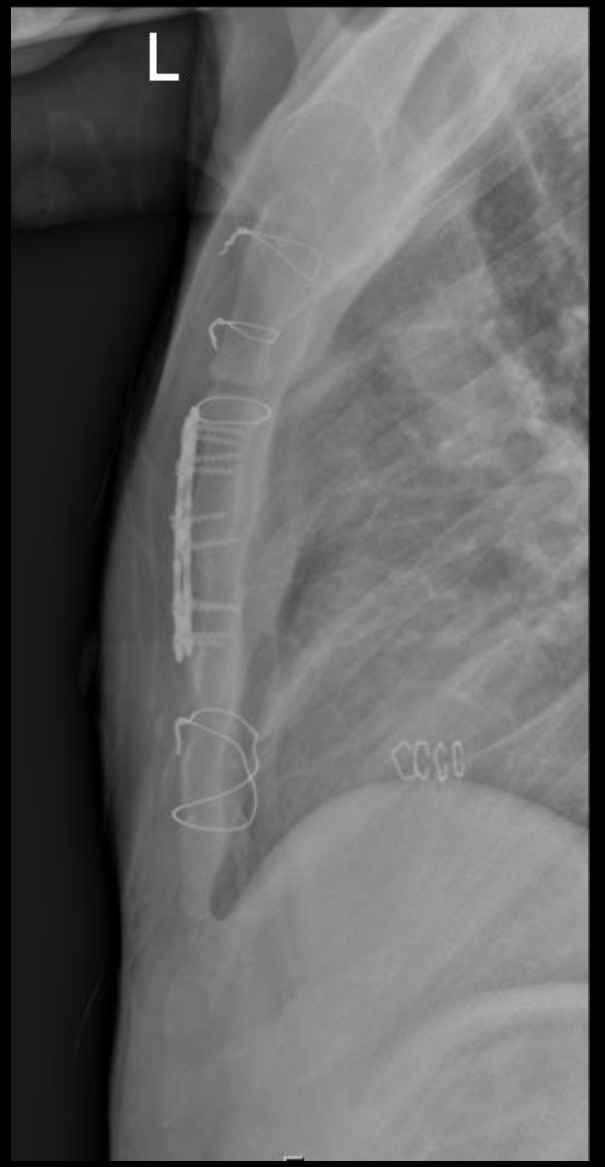
- Sternum: transverse Fx.

➔ Bone bleeding

- Hematoma (+)
- LIMA branch: 2 site

➔Arterial bleeding





Subcutaneous emphysema

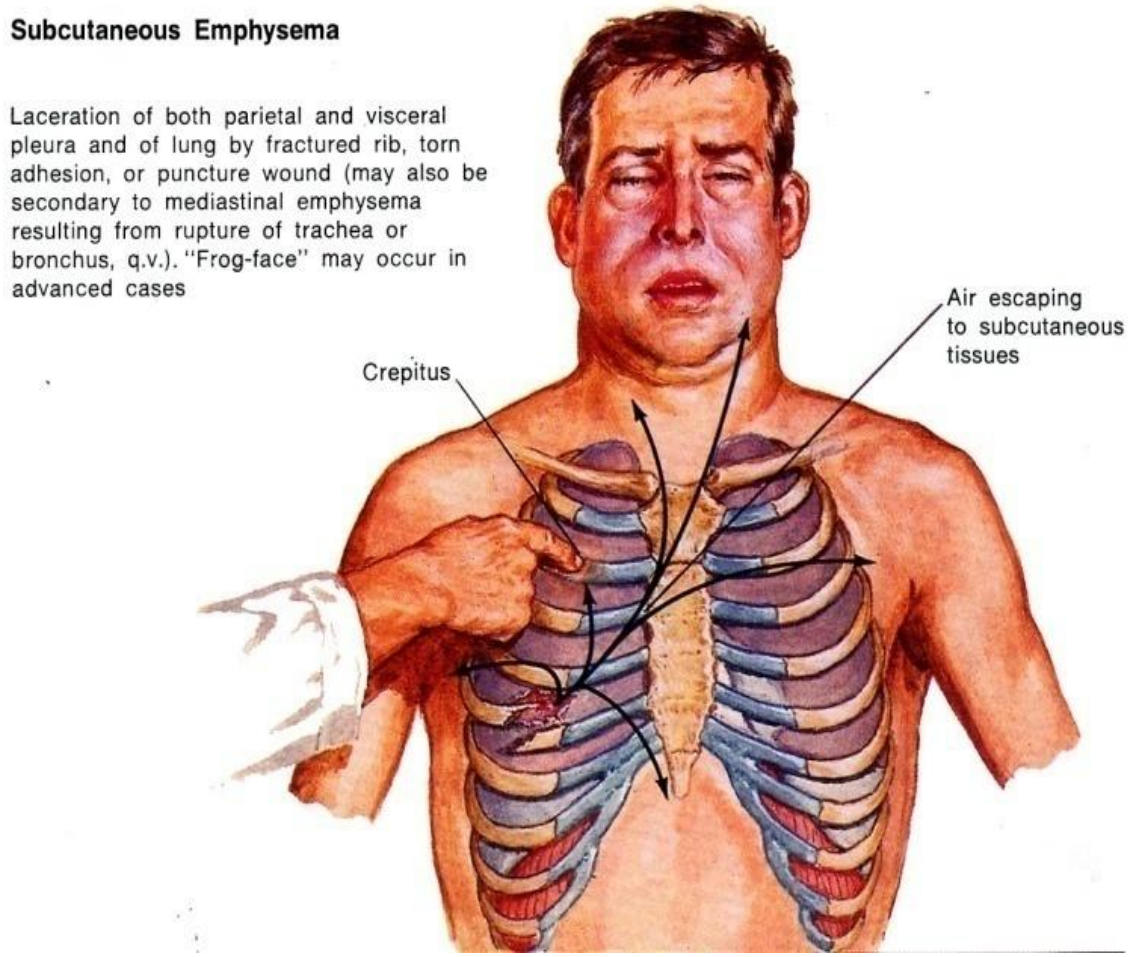
- Tracking of air into subcutaneous layer
- Feel spongy and crunchy to the touch
- Distorting the vocal cord - arrest

Tx: prophylactic antibiotics

mild – observation

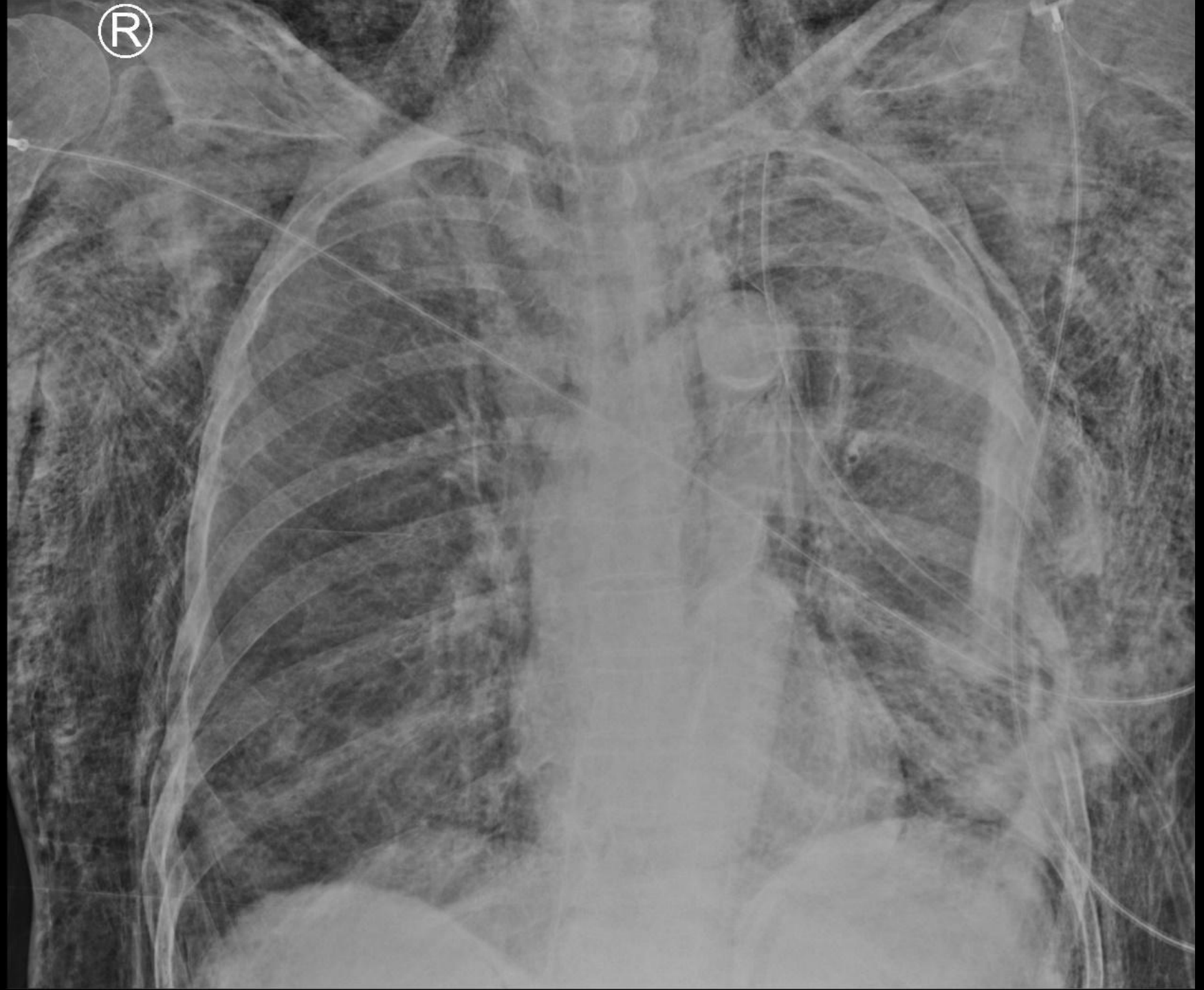
severe – additional tube

high power suction etc



Case

- F/66
- Slip down, 가구 모서리에 좌측 가슴을 부딪힘
- 타병원 방문, T-pneumothorax c severe subcutaneous emphysema Dx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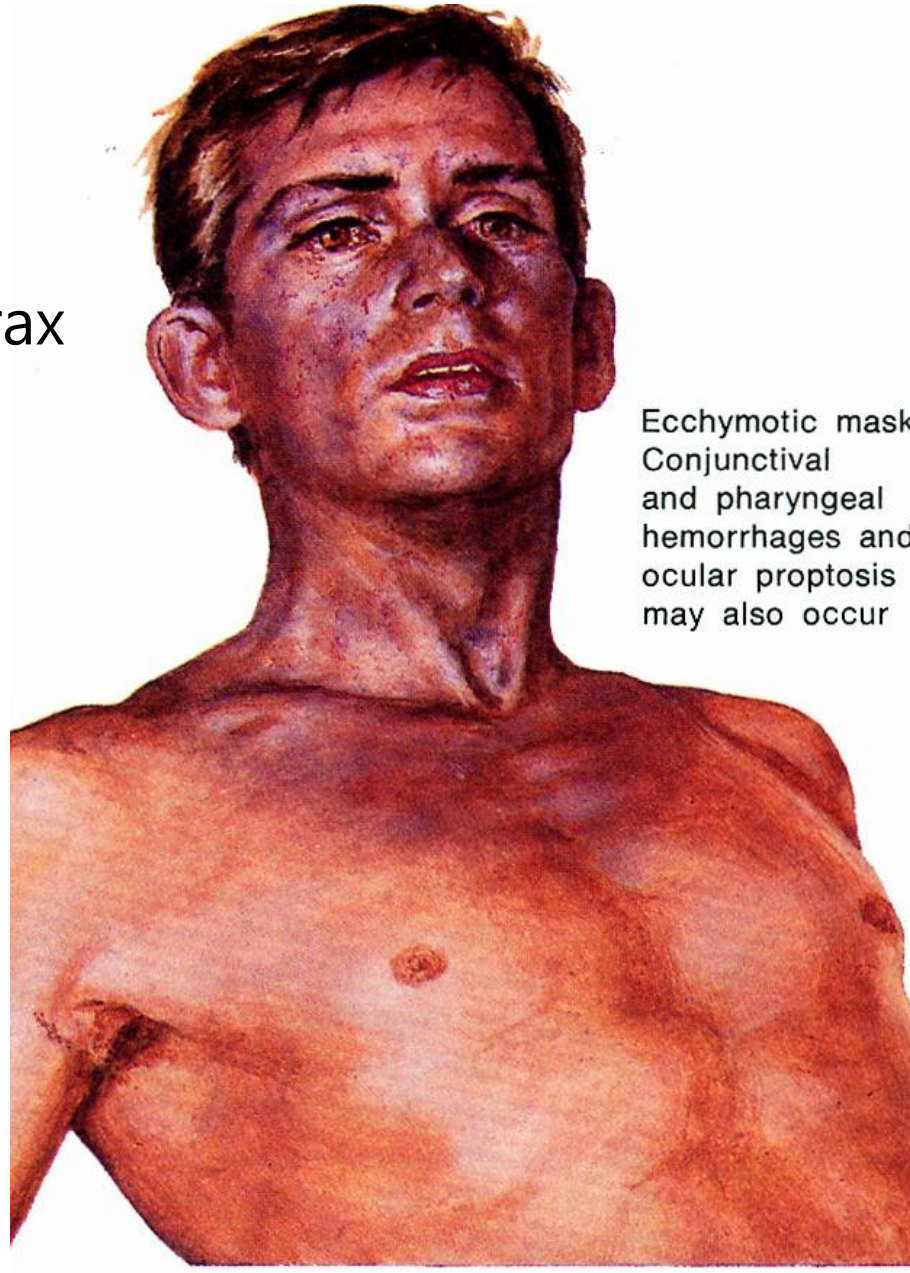
Traumatic asphyxia

- Powerful compressive force ➔ Pressure to thorax
- Upper extremities: cyanosis

  Neck and head: Petechiae

  Jugular venous distention and facial edema

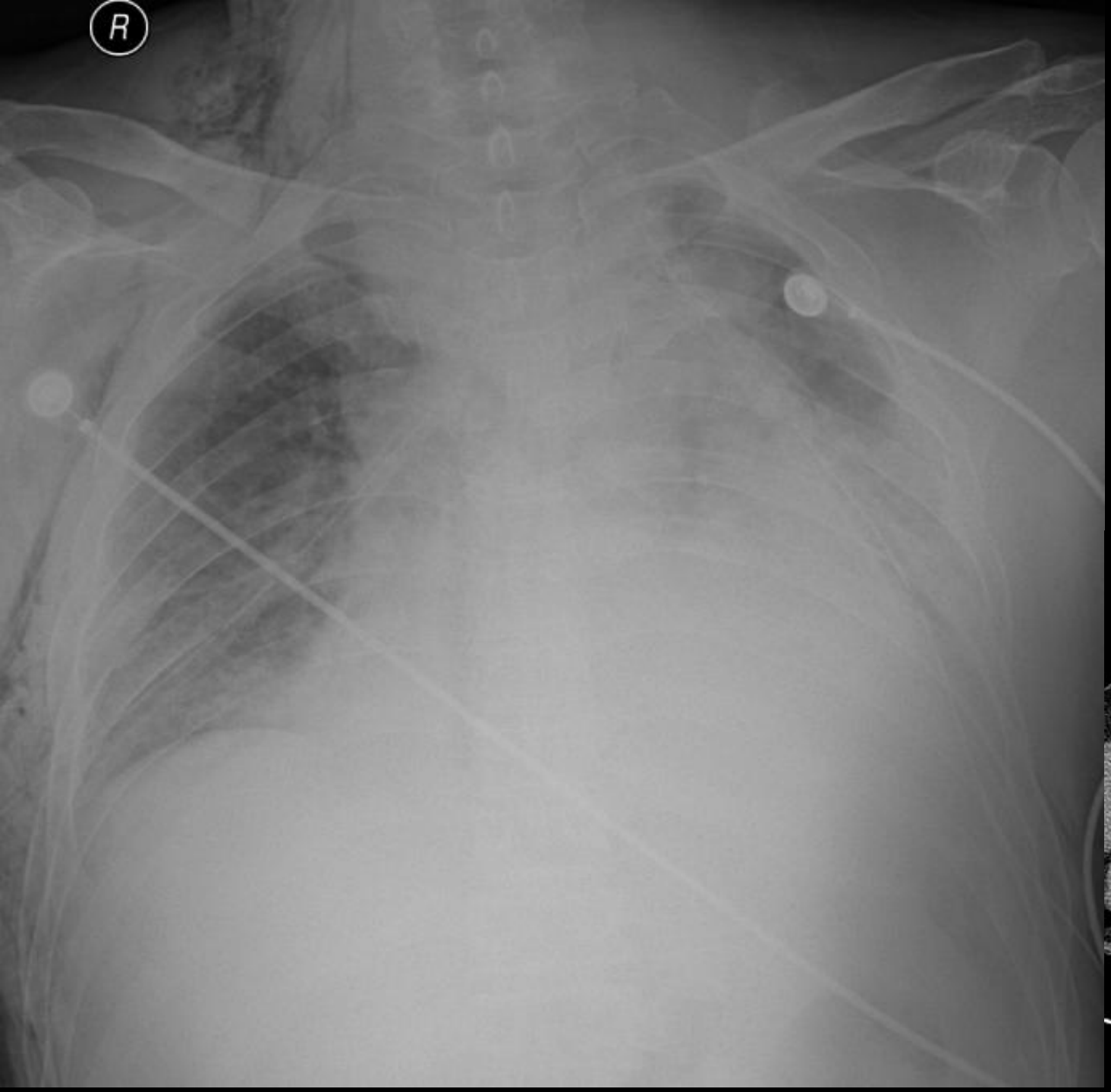


Thoracic duct injury

- Marked nutritional depletion
- C-tube: chylous material draining, milky
- Tx: NPO, devoid of long-chain fatty acid, Operation

Case

- M/60
- C/C: bleeding on forehead and nose
- 택시 조수석 TA
- V/S: 160/137 mmHg - 88 /min - 24/min
- GCS: E4M6V5
- PMHx: HTN(+): medication (aspirin-)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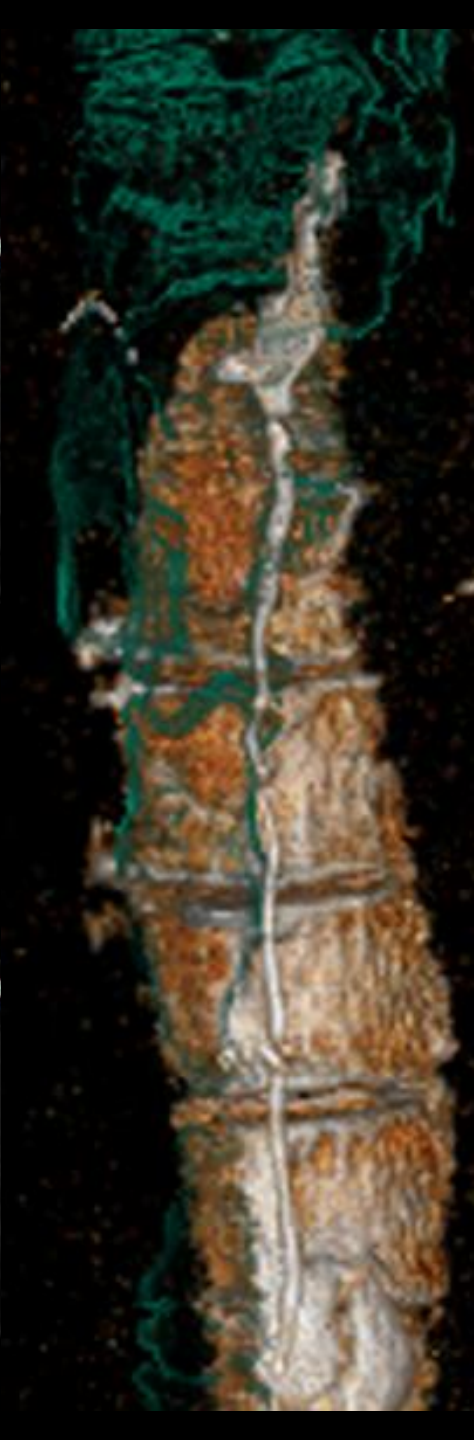
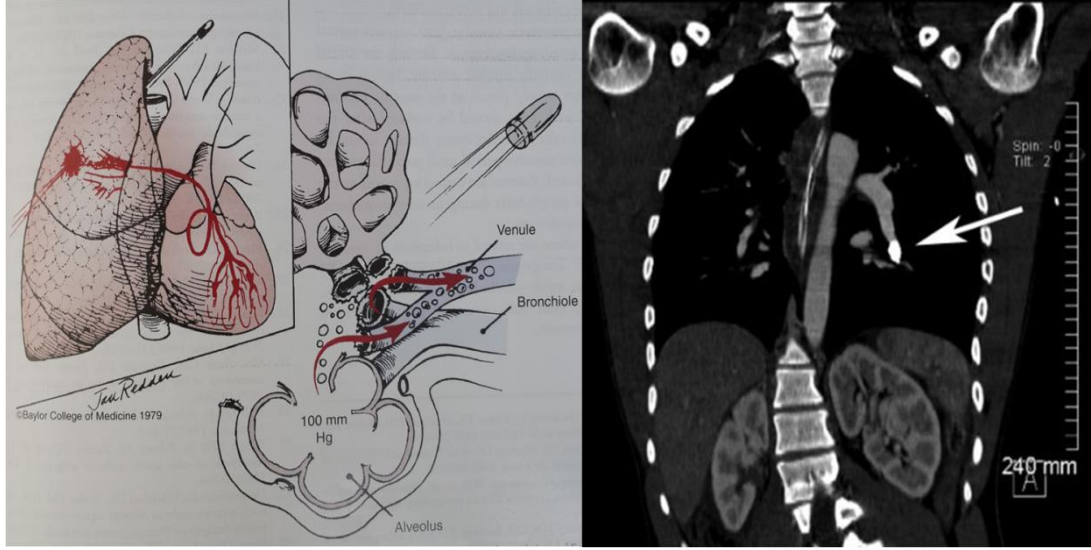
130 mm
130 mm


Lipiodol Injection : 7.2ml

70
70


Embolism



- Systemic air embolism
  - Fistula between a pulmonary vein and bronchiole d/t penetrating lung injury
  - Manifestation: seizure, cardiac arrest
- Foreign body embolism
  - Intravascular bullet emboli, catheter
  - 25% migration ➔ finally lodge in the pulmonary arteries
  - Removed to prevent pulmonary thrombosis, sepsis etc.


スラムダンク
SLAM DUNK
SHOHOKU
14
11
10

그래도 끝까지 포기하지마

NEVER EVER GIVE UP!

OUR MISSION

YOUR LIFE