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| 關懷 | 創新 | 智能 | 永續 |

急重症心血管影像判讀

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115.8.1

授課大綱

- 各種導管的位置及併發症 (catheters, tubes, lines)
- 氣壓傷害 (barotrauma)
- 肺水腫 (cardiogenic pulmonary edema vs ARDS)
- 水分之評估 (fluid status evaluation)
- 肺塌陷 (lung atelectasis)
- 肺栓塞 (pulmonary embolism)

ICU CXR之特性

- Portable
- Supine
- AP view
- Poor inspiration (Hypoinflation), effects of MV (Hyperinflation)
- Catheters, tubes, lines...

Supine vs Upright

- 不易看出air-fluid level
- Pleural effusion及pneumothorax 之表現不同，較不易評估
- 上肺野之血管徑在躺著時會變粗 (cephalization)

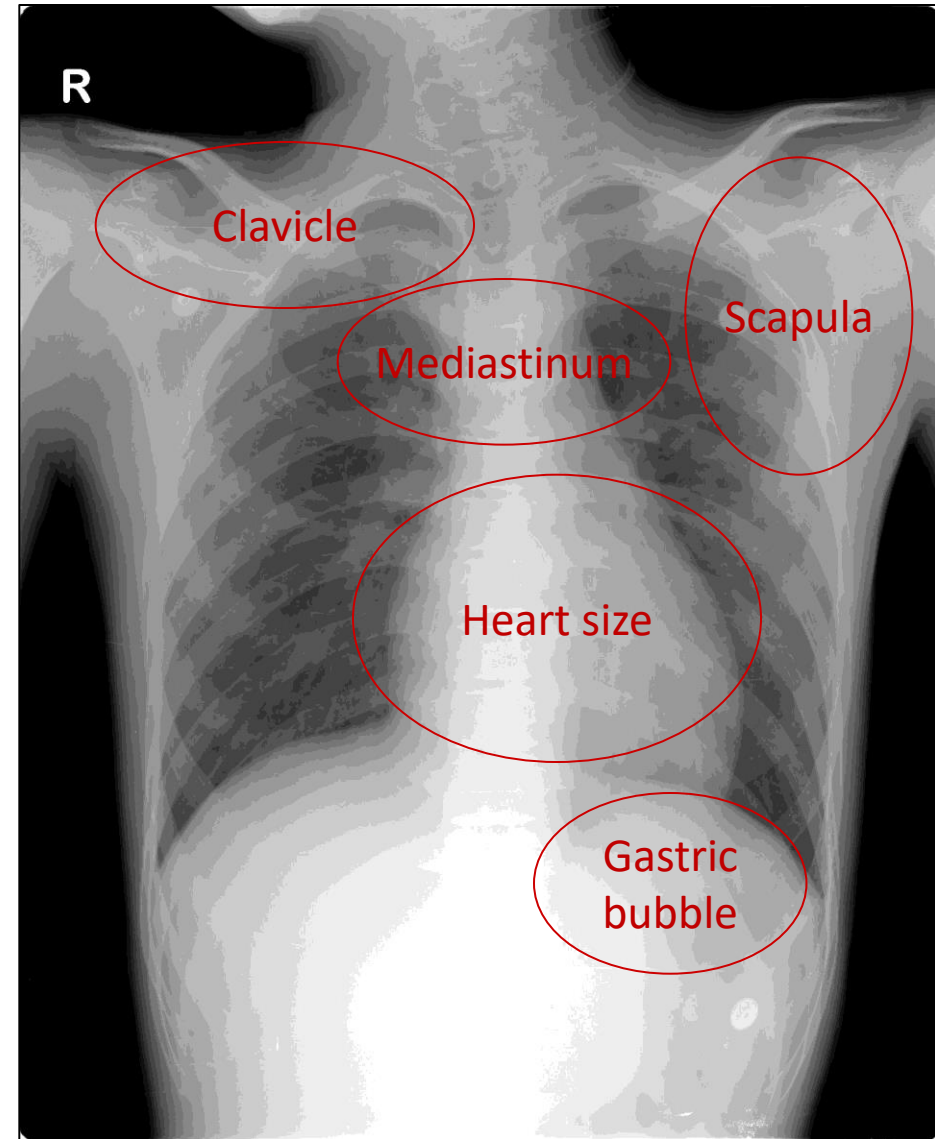
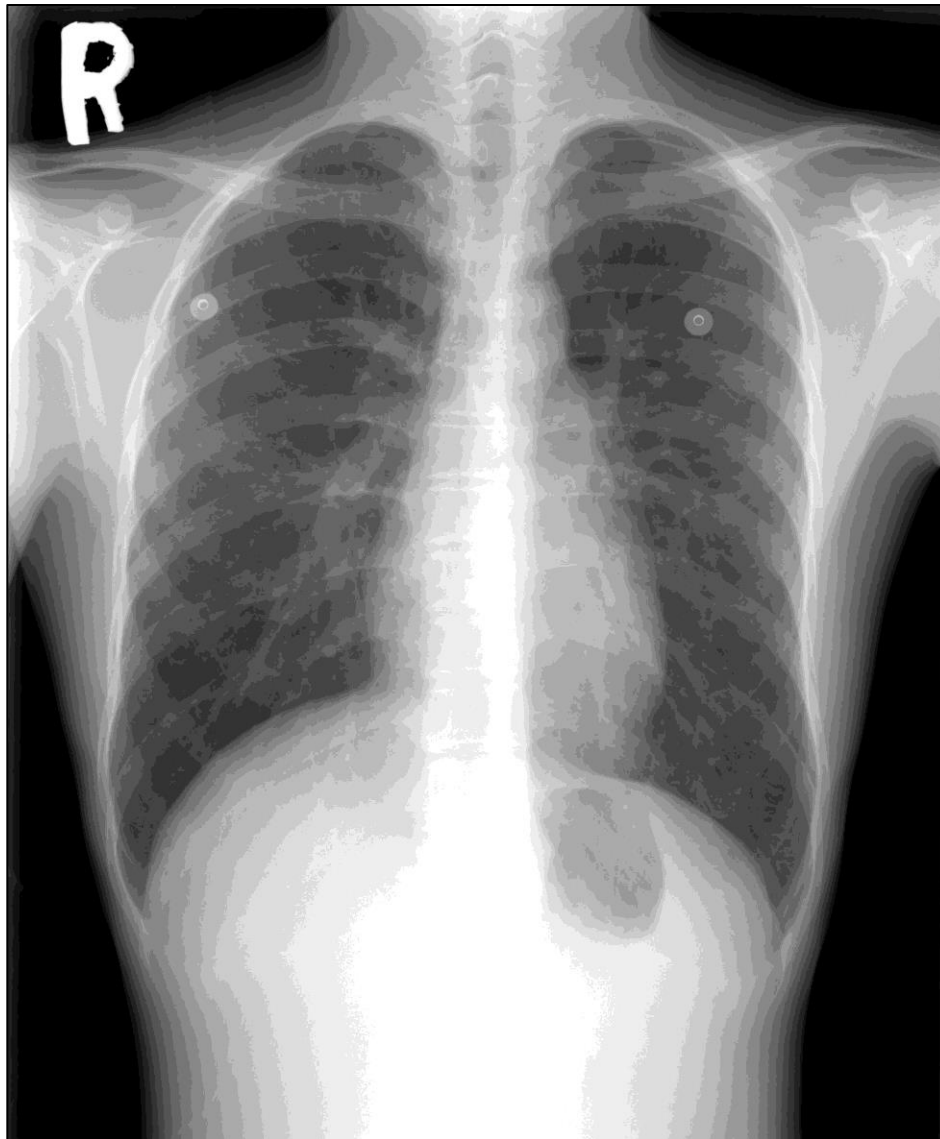
Hypo- or Hyper- inflation

- 重症病患或使用呼吸器病患無法配合吸飽氣照，將使肺浸潤看起來更加惡化
- 使用呼吸器之病患若有過度充氣 (hyperinflation or air-trapping)，將使肺浸潤看起來呈假像的改善

Catheters, Tubes, Lines

- 重症病患身上常置入多種導管，須小心評估其位置是否正確，有無發生併發症。

- Nasogastric tube
- Endotracheal tube
- Tracheostomy tube
- Central venous catheter
- Esophageal temperature probe
- Hemo-cath
- Pulmonary artery catheter
- Chest tube
- Pigtail drain tube
- Pacemaker
- IABP
- ECMO



加護病房病患為何要照CXR

- 確定各種導管的位置及可能發生的併發症
- 追蹤原本的心肺疾病
- 監測使用呼吸器患者肺部的變化及氣壓傷害
- 評估心臟血行動力學的變化 (水分的評估)
- 診斷出臨床未預期的新病變

加護病房病患何時需照CXR

- 住進加護病房時
- 臨床狀況改變時
- 侵襲性處置後（即使導管置放失敗）
- 適時追蹤病情之變化
- 每天例行性照胸部x光
 - Acute cardiopulmonary disease
 - Invasive mechanical ventilation
 - Arterial catheter (PAC, IABP...)

Catheters & Tubes & Lines

Endotracheal Tube

- The position of the tip of the endotracheal tube can vary with neck position (see next page)
 - *Neck extension causes a 2-cm ascent of the tip*
 - *Neck flexion causes a 2-cm descent of the tip*
- When head and neck are in the neutral position, the tip of the ET tube should rest at about **5 cm** above the **carina** and at **least 3 cm distal** to the **vocal cords** (American College of Radiology)
- The carina is located on radiographs at the 4th rib or the T4-T5 interspace.

Endotracheal Tube

- **Using the MANDIBLE as a guide**

- Neck extension (inf. border of mandible above C4)
 - Tip of tube: 7 ± 2 cm from carina
- Neutral (inferior border of mandible at C5-6)
 - Tip: 5 ± 2 cm
- Neck flexion (inf. border of mandible below T1)
 - Tip: 3 ± 2 cm

- **Width: $1/2 - 2/3$ of trachea**

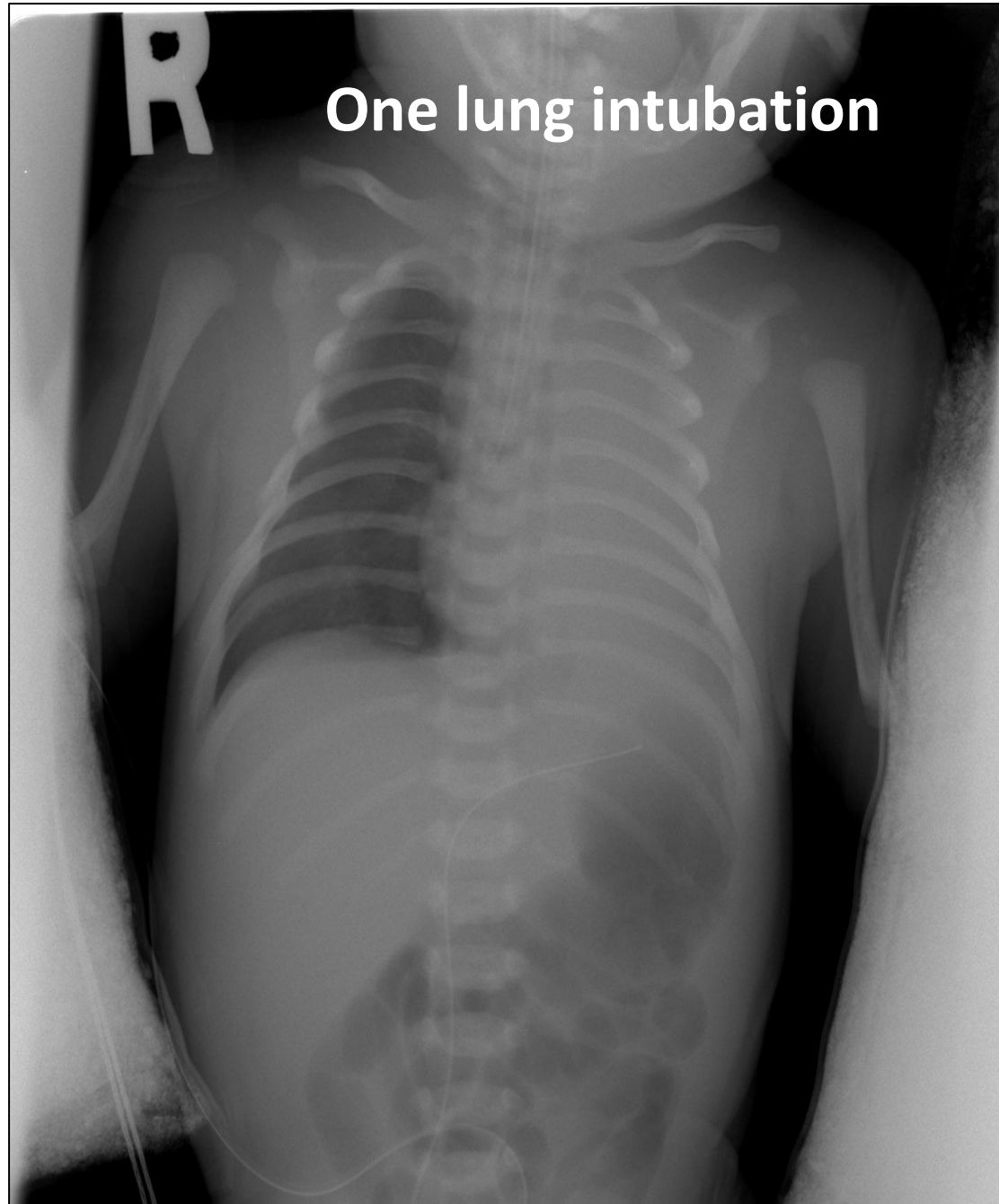
- **Cuff:**

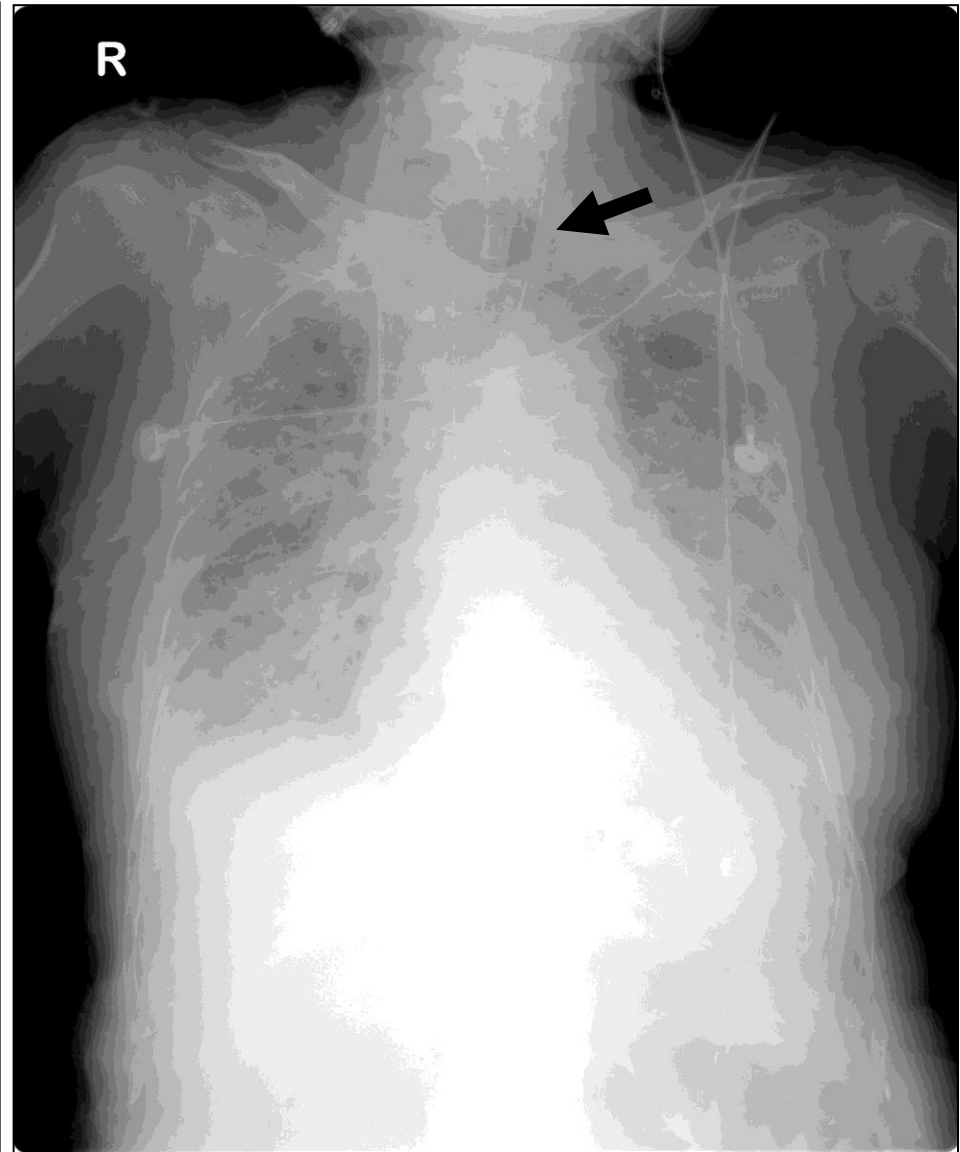
- Inflate to occlude the trachea but do not exceed the diameter of trachea. Balloon of 1.5X the diameter of trachea will cause tracheal injury.

Endotracheal Tube

- **Complications:**

- **One lung intubation** (usually right main)
 - Hyperinflation of right lung
→ emphysema, pneumothorax
 - Atelectasis of left lung
- **Esophageal intubation**
 - E-T tube not in the trachea
 - Gastric distention
- **Tracheal rupture** (usually within 7 cm of the carina)
 - Pneumomediastinum, pneumothorax, subcutaneous emphysema..
- **Aspiration (pneumonitis)/ Infection (pneumonia)**







Tracheostomy Tube

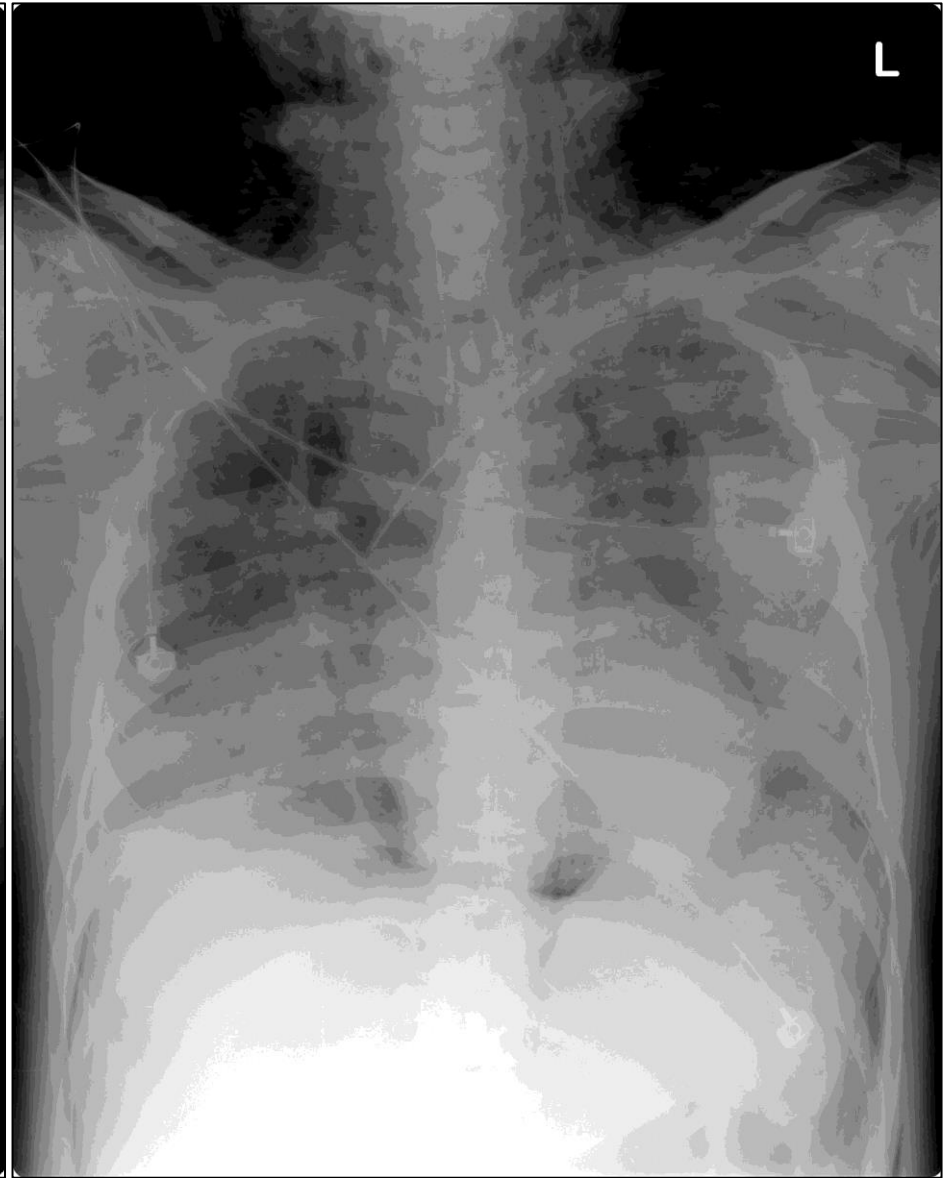
- Tip: $1/2 - 2/3$ between stoma & carina
- Inner diameter: $2/3$ of tracheal lumen
- Long axis: parallel to tracheal wall
- Distal end: Do not abut tracheal wall

Percutaneous Dilational Tracheostomy

- **Complications:**

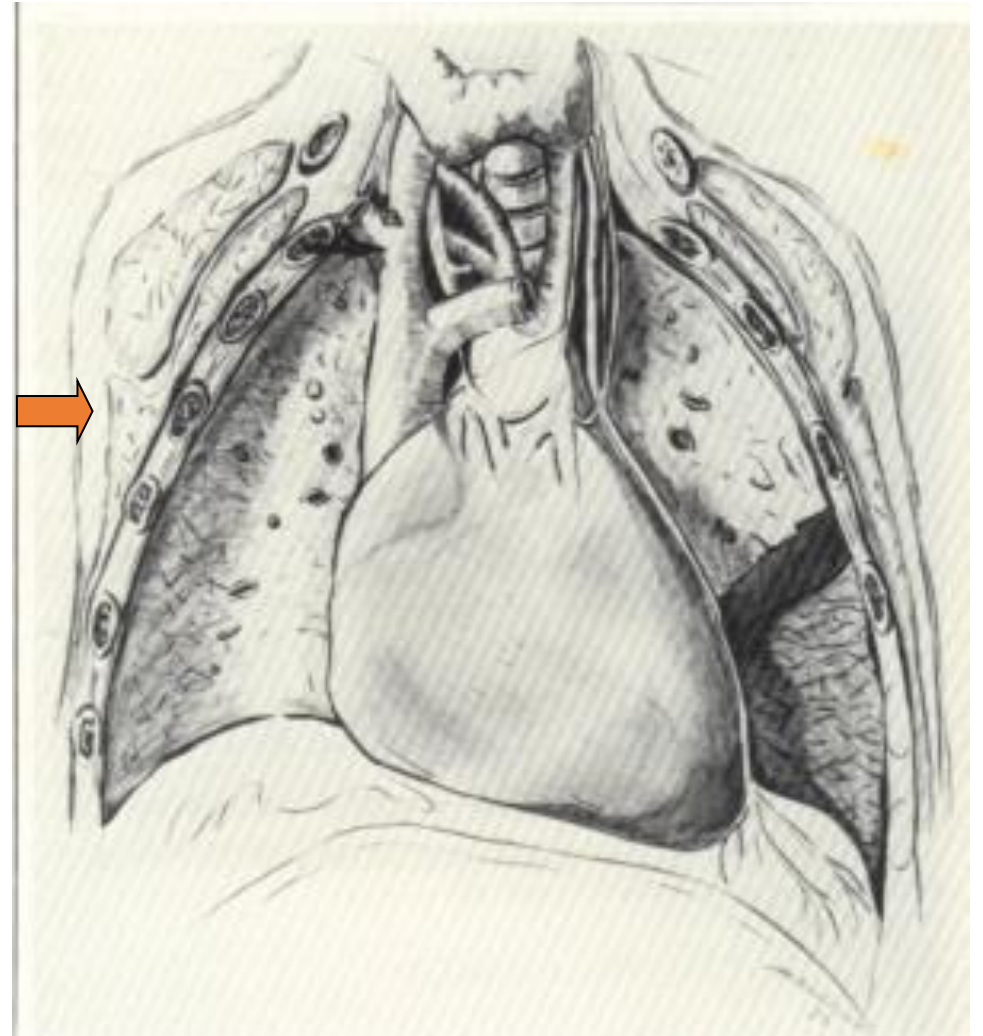
- Malposition of tracheostomy tube (false lumen)
- Tracheal rupture -> pneumomediastinum
- Subcutaneous emphysema, pneumothorax

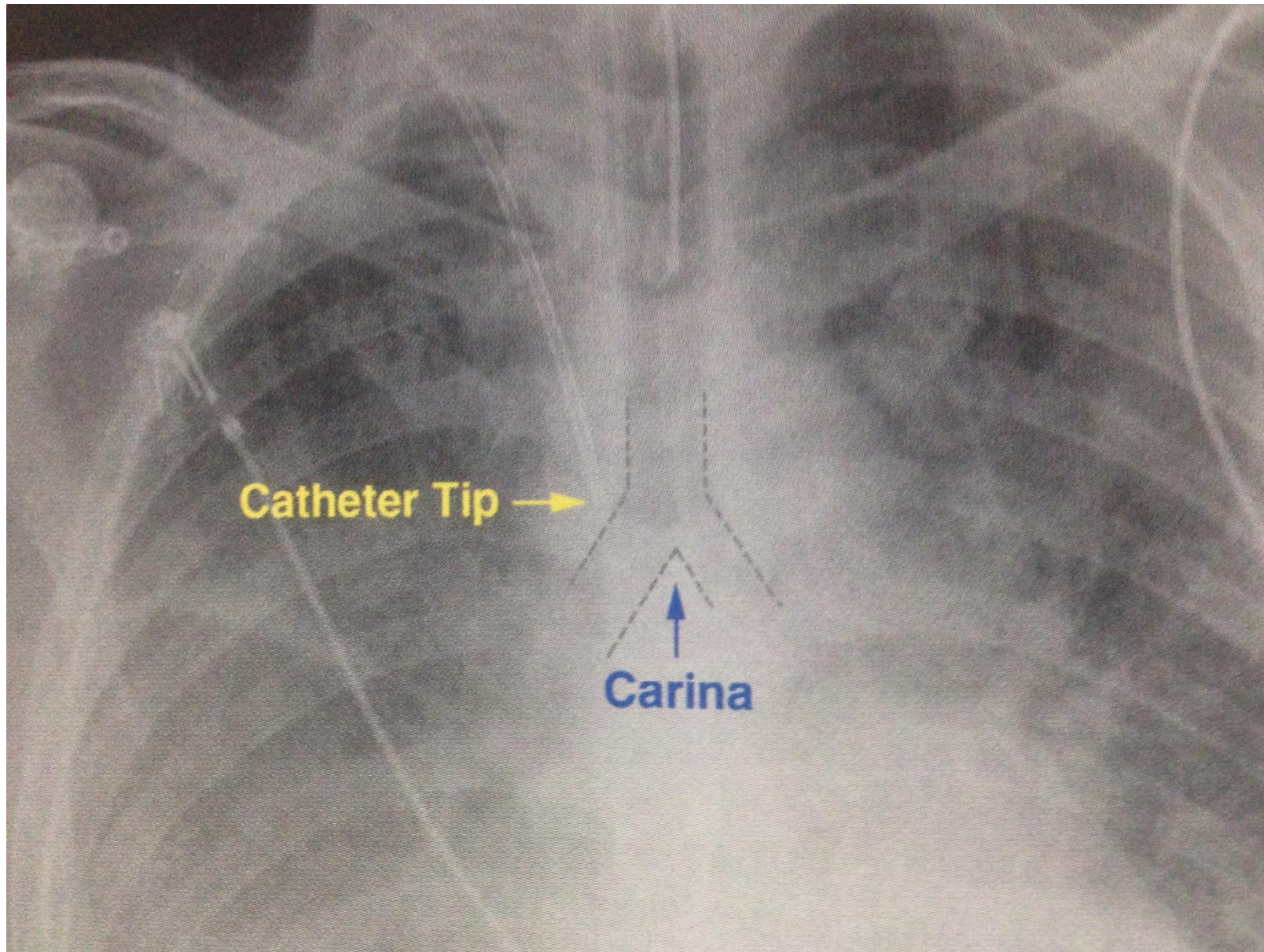
- Bleeding
- Over-inflation of cuff
- Infection (pneumonia)



Central Venous Catheter

- In SVC
- Tip:
 - below right brachiocephalic v. (anterior first rib) and slightly above the right atrium
 - at the level of or slightly above the azygos vein
- As many as 30% of CVP catheters are initially placed incorrectly.





Central Venous Catheter

- **Complications:**

- **Malposition: up to 40%**

- In pleural space or In mediastinum
 - Vessel perforation
 - Pleural effusion or widening of mediastinum
 - In other veins
 - Too distal (inadequately advanced) [放太淺]
 - The proximal port will not beyond venous valves
 - Tip beyond azygos vein [放太深]
 - SVC become intrapericardial, vessel rupture will result in pericardial effusion or even tamponade

Central Venous Catheter

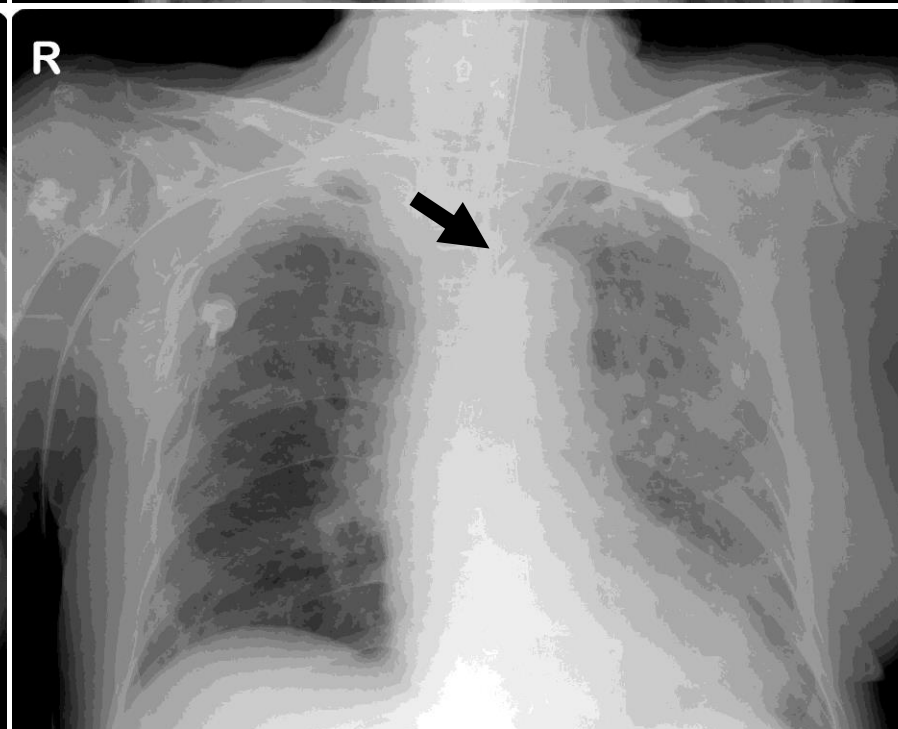
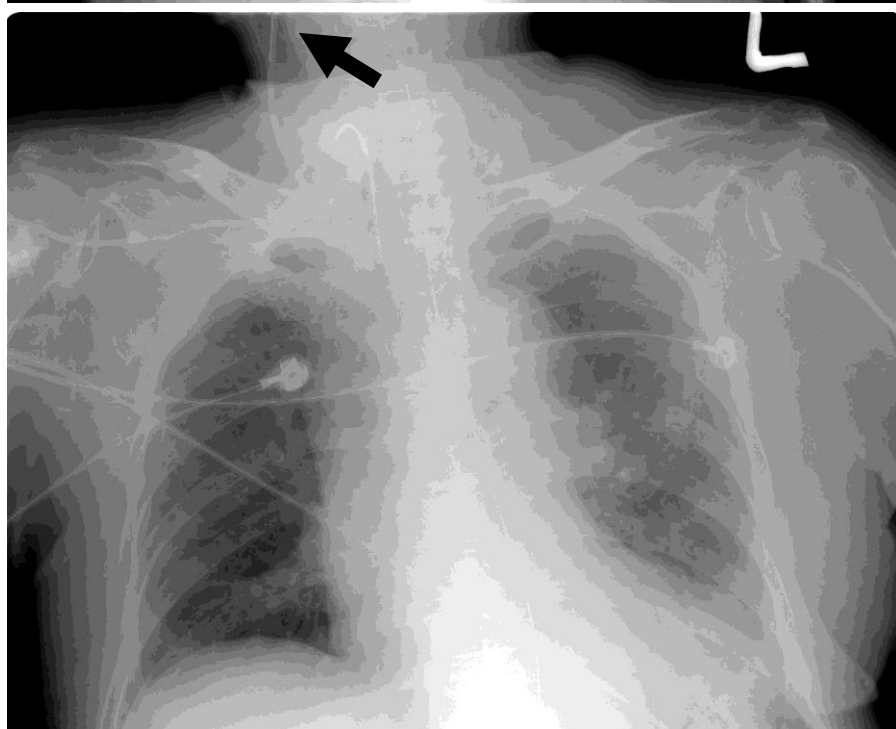
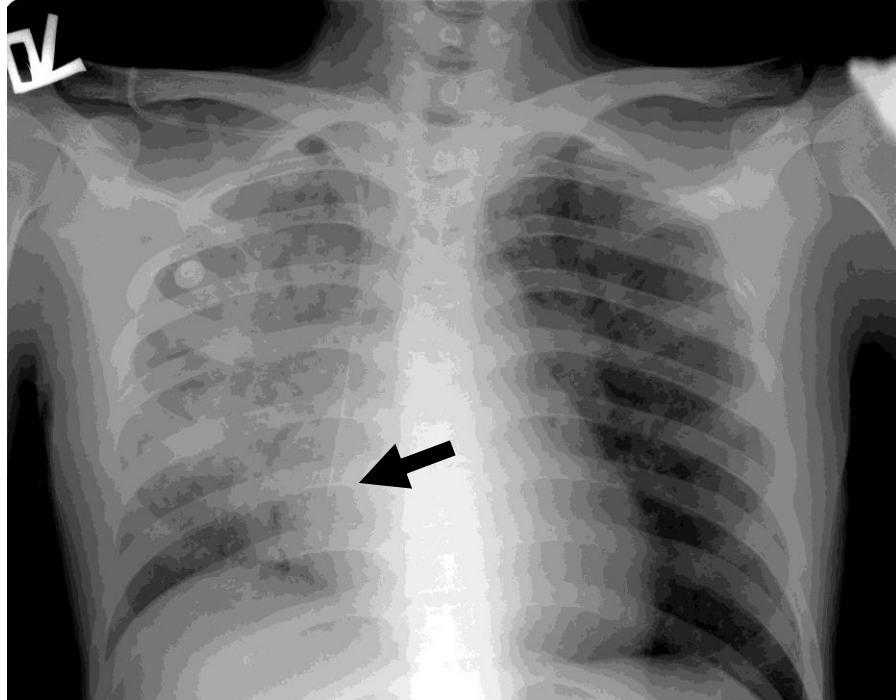
- **Complications:**

- **Malposition (Cont.):**

- In RA
 - Arrhythmia, cardiac perforation
 - Catheter tip directed against the wall of SVC
 - Easy vessel perforation

- **Pneumothorax:** up to 5%

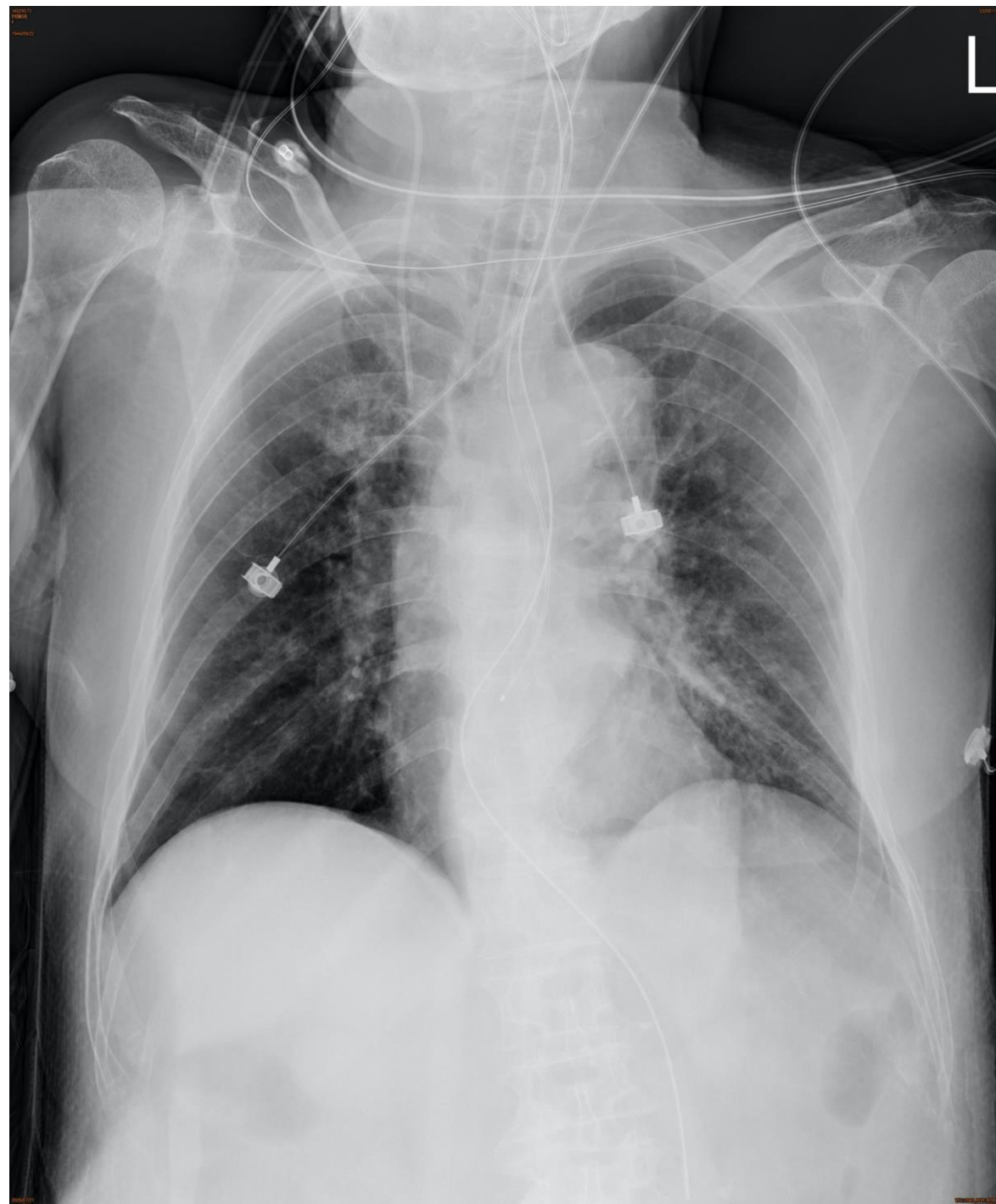
- Obtain a portable CXR even after a failed attempt to place a central line





Esophageal temperature probe

- Place in the lower third of the esophagus



Pulmonary Artery Catheter

- Swan-Ganz Catheter

- Tip: in RPA or LPA

- The tip should never be lodged beyond a major pulmonary artery (RPA, LPA or proximal interlobar artery)
 - Within 2 cm from hilum

Pulmonary Artery Catheter

- **Complications:**

- **Malposition: 24%**

- *Even initial position is correct, distal migration may occur. Daily CXR is recommended*

- **Pulmonary infarction**

- **Pulmonary artery rupture**

- Pulmonary hemorrhage

- **PA pseudoaneurysm**

- May present as a new solitary pulmonary nodule months after discharge from ICU



IABP (intra-aortic balloon pump)

- Inflate in diastole; deflate in systole
- The balloon is in thoracic aorta
- Tip is ideally located in the descending aorta, 2 cm distal to the origin of left subclavian a. (just caudal to the aortic arch)

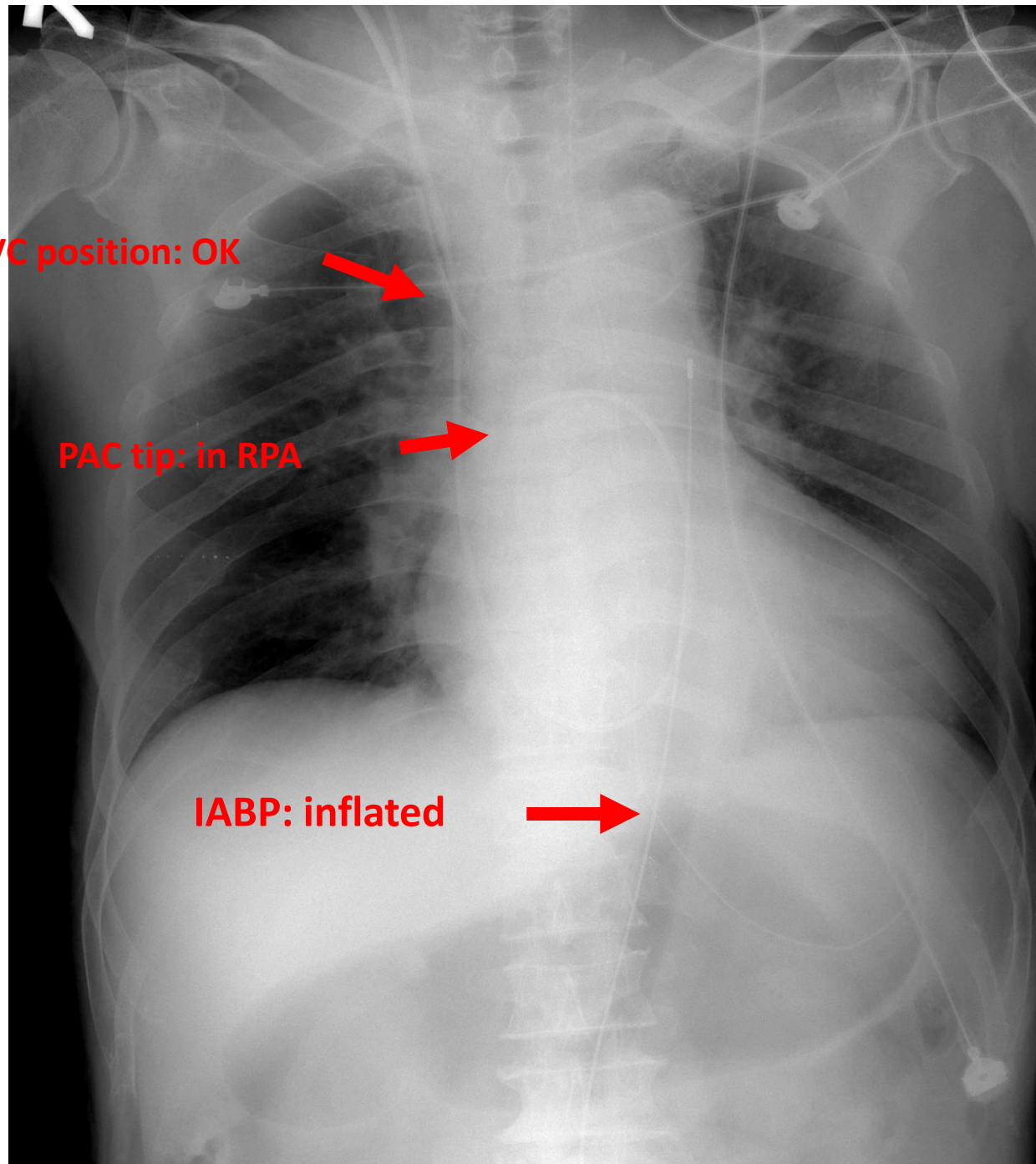
IABP (intra-aortic balloon pump)

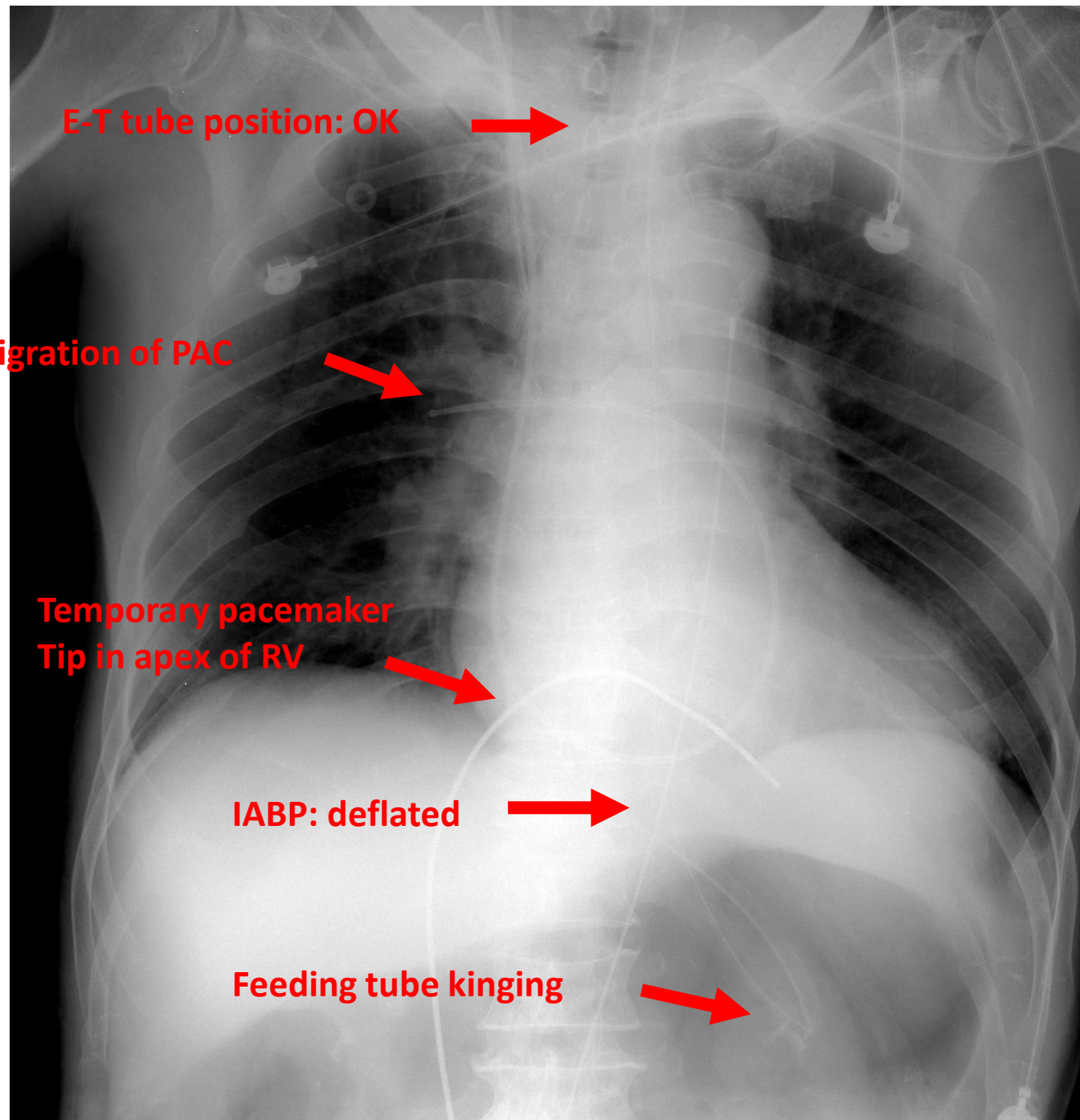
- **Complications: 8-36%**
 - **Proximal migration of tip:**
 - Cerebral, vertebral, subclavian a. obstruction
 - **Distal migration of tip:**
 - Mesenteric and renal a. obstruction
 - **Other complications:**
 - Aortic dissection
 - Balloon rupture with gas embolization

CVC position: OK

PAC tip: in RPA

IABP: inflated





E-T tube position: OK



Distal migration of PAC



**Temporary pacemaker
Tip in apex of RV**



IABP: deflated



Feeding tube kinging



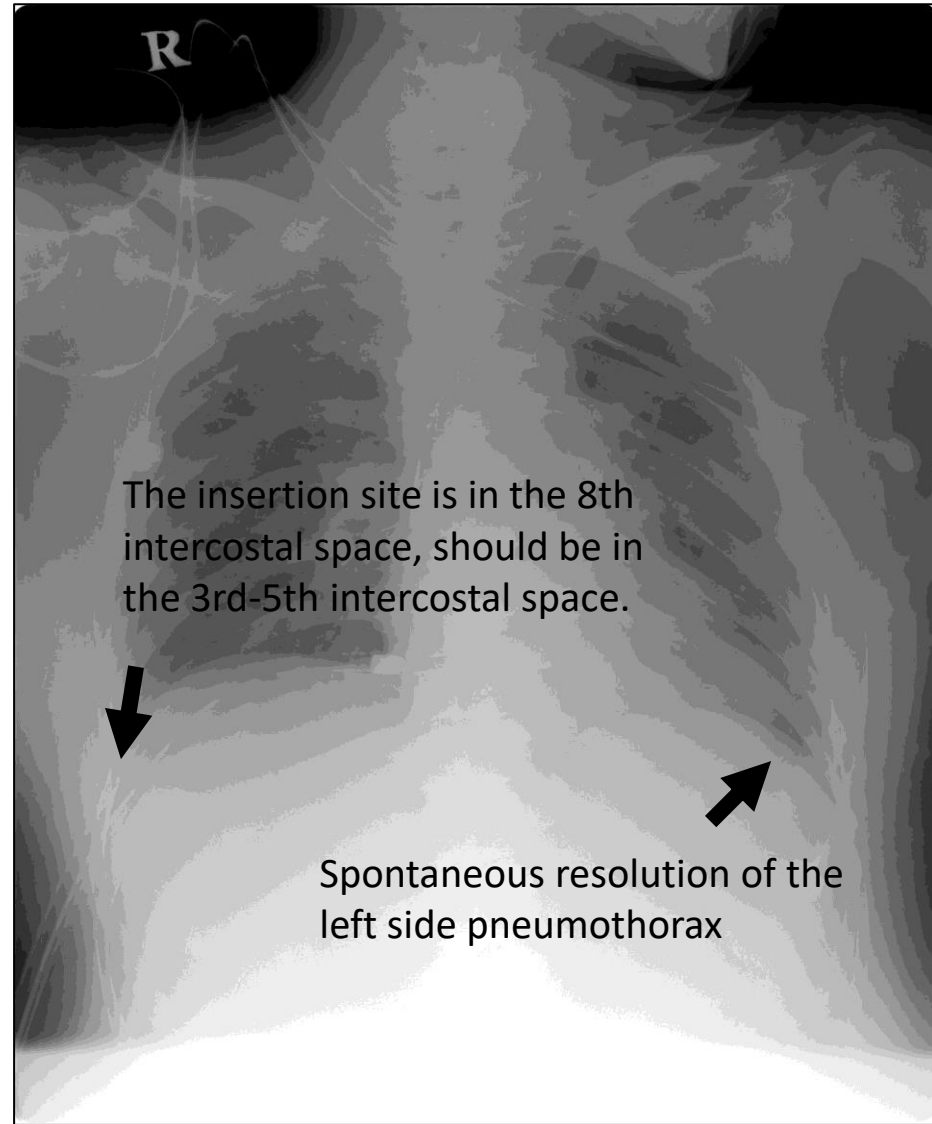
Chest Tube

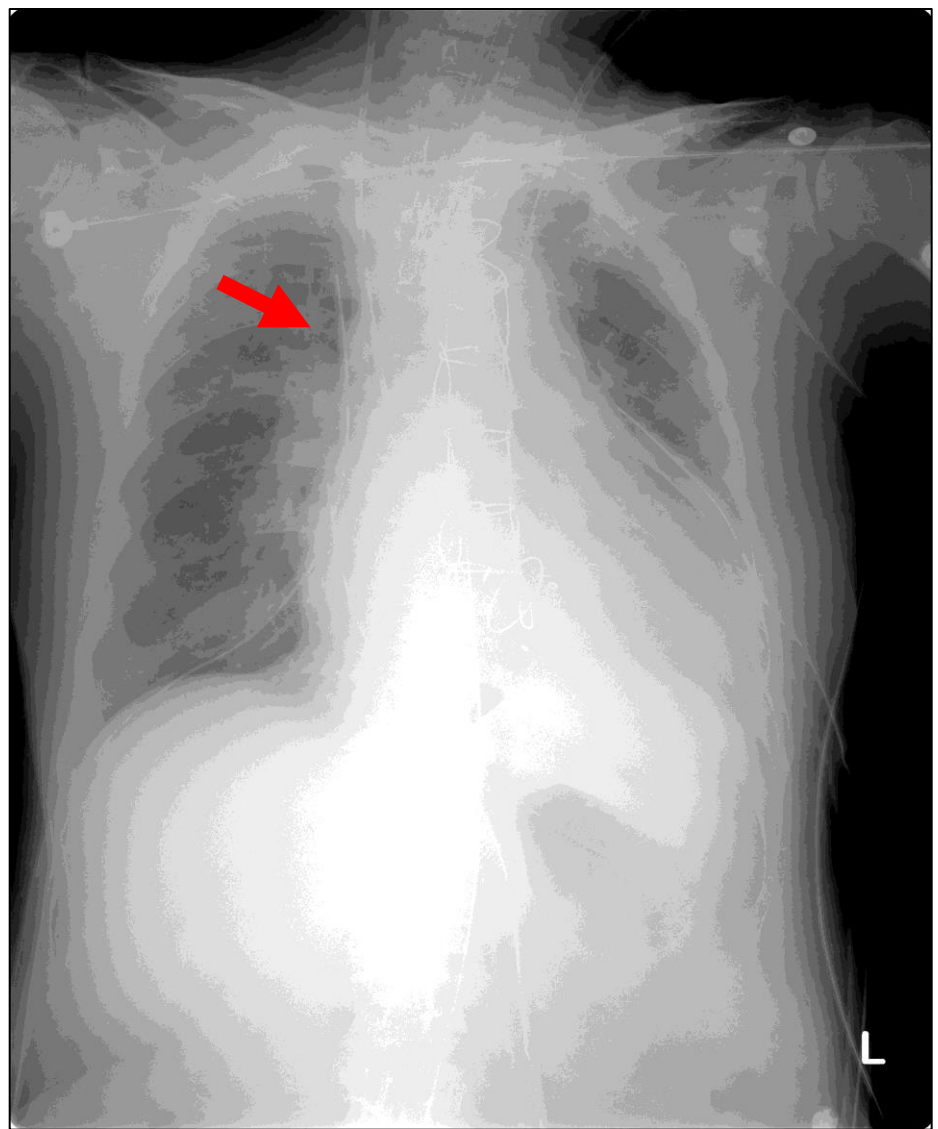
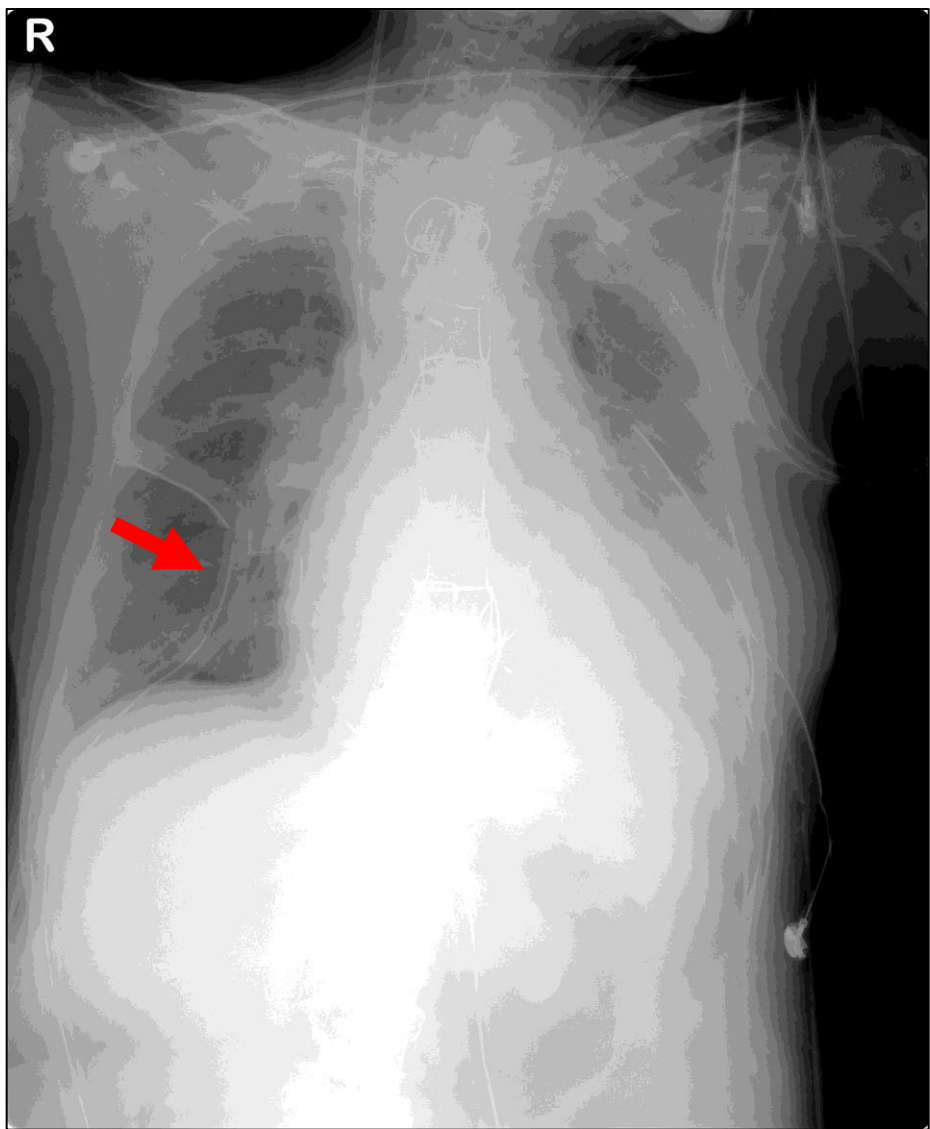
- To drain air (pneumothorax) or fluid (pleural effusion or empyema). Air will be collected **anteriomedially**, fluid will be collected **posteriorly**
- Insertion site: the **4th intercostal space** (about the level of nipple) at ant- or mid- axillary line
- The tip should ideally be aimed **apically**, except for drainage of loculated pleural fluid.
- The side holes should be always positioned medial to the inner margin of ribs

Chest Tube

- **Complications:**

- Lung, mediastinum penetration
- Liver, spleen, and diaphragm trauma
- Chest tube In the fissure
- Chest tube in the subcutaneous tissue
- Side hole in the subcutaneous tissue
- Subcutaneous emphysema
- Hemorrhage





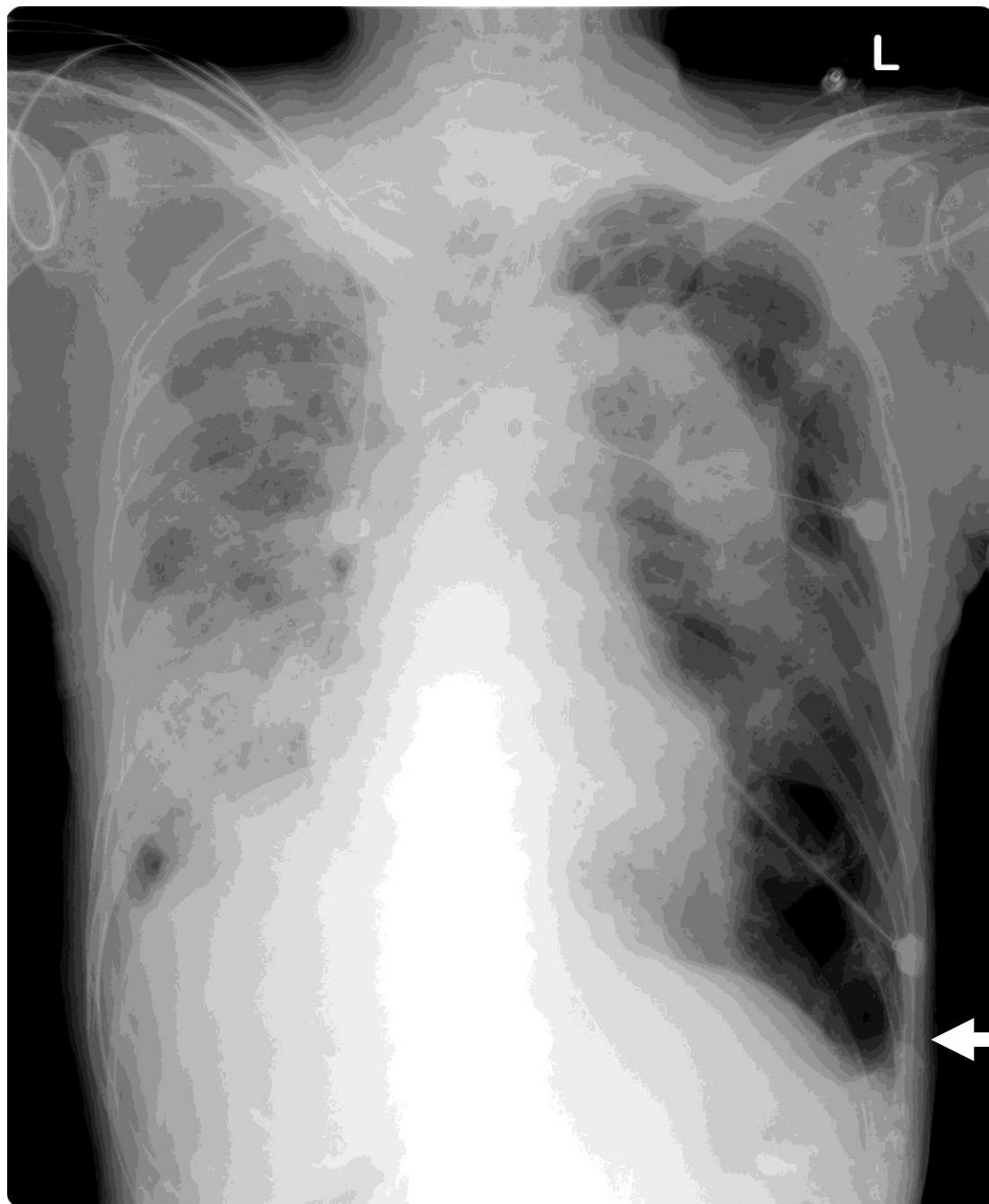
Barotrauma

Barotrauma

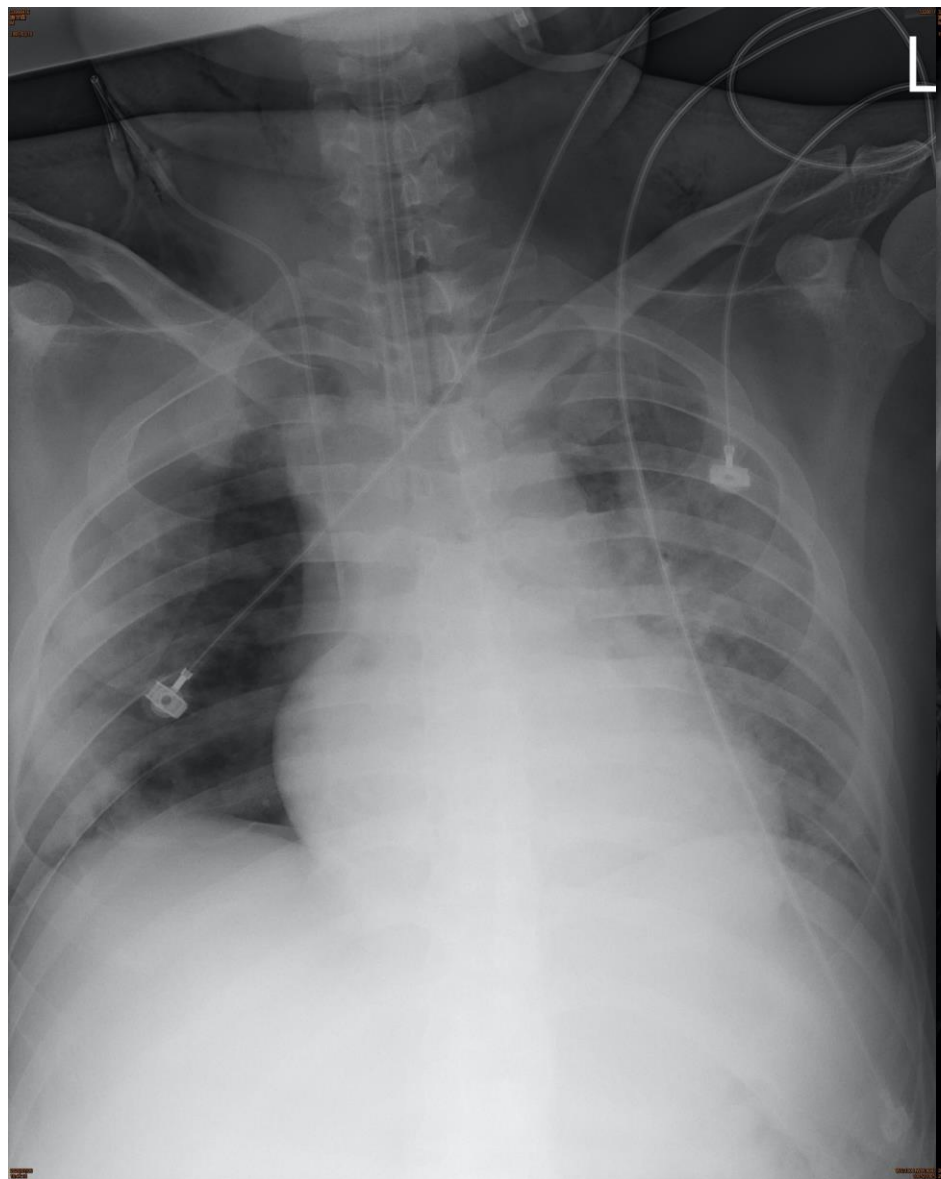
- Ventilator associated lung injury:
 - (Oxygen toxicity)
 - Volumetrauma
 - Atelectrauma
 - Biotrauma
 - Barotrauma: Presence of extra-alveolar air

Barotrauma

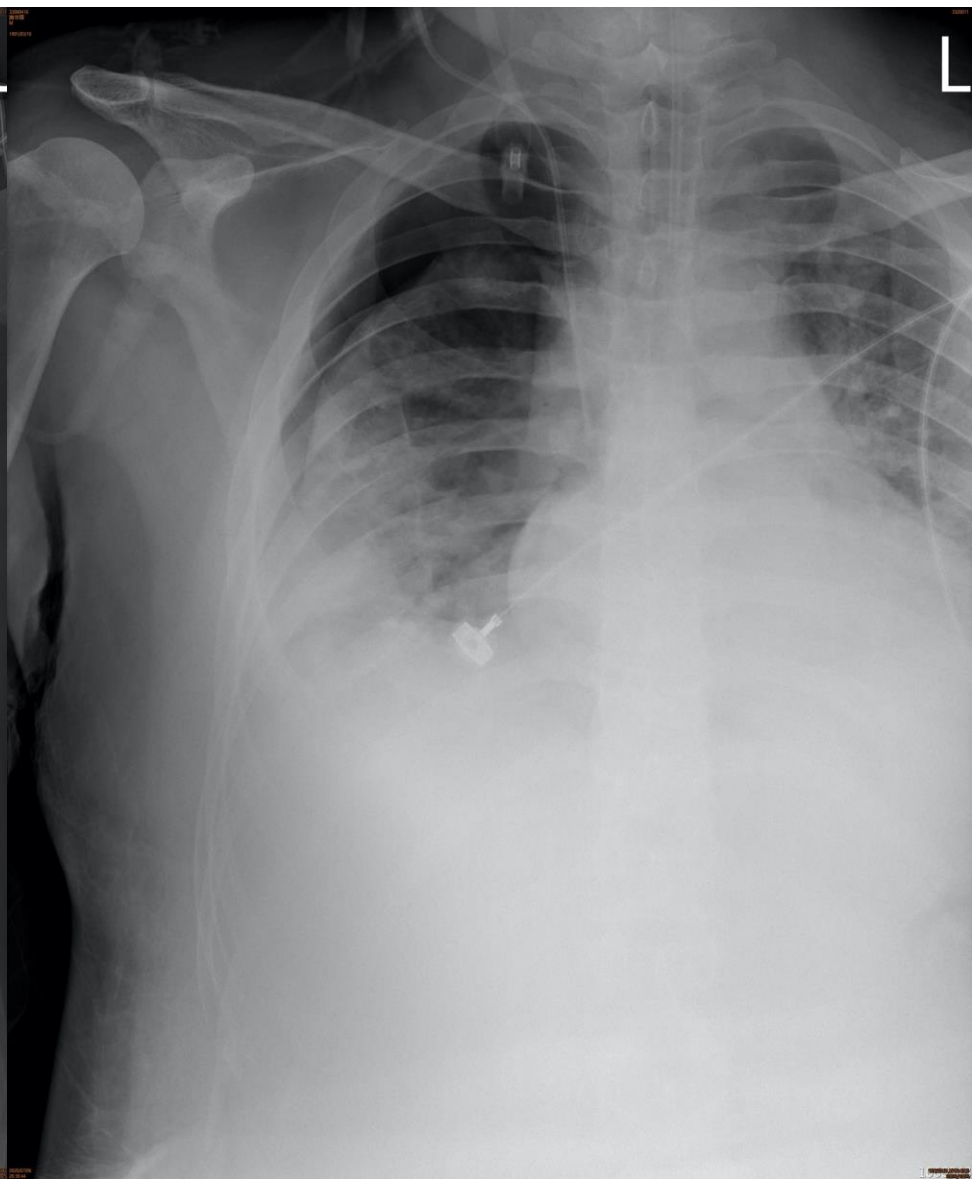
- High airway pressures can cause gross injury manifest as air leaks
 - Air get access into the interstitial tissues → track along the bronchovascular sheath → into mediastinum
- **Manifestations: (extra-alveolar air)**
 - *Pulmonary interstitial emphysema*
 - *Pneumomediastinum*
 - *Subcutaneous emphysema*
 - *Pneumothorax*
 - *Pneumopericardium,*
 - *Pneumoretroperitoneum,*
 - *Systemic embolism*

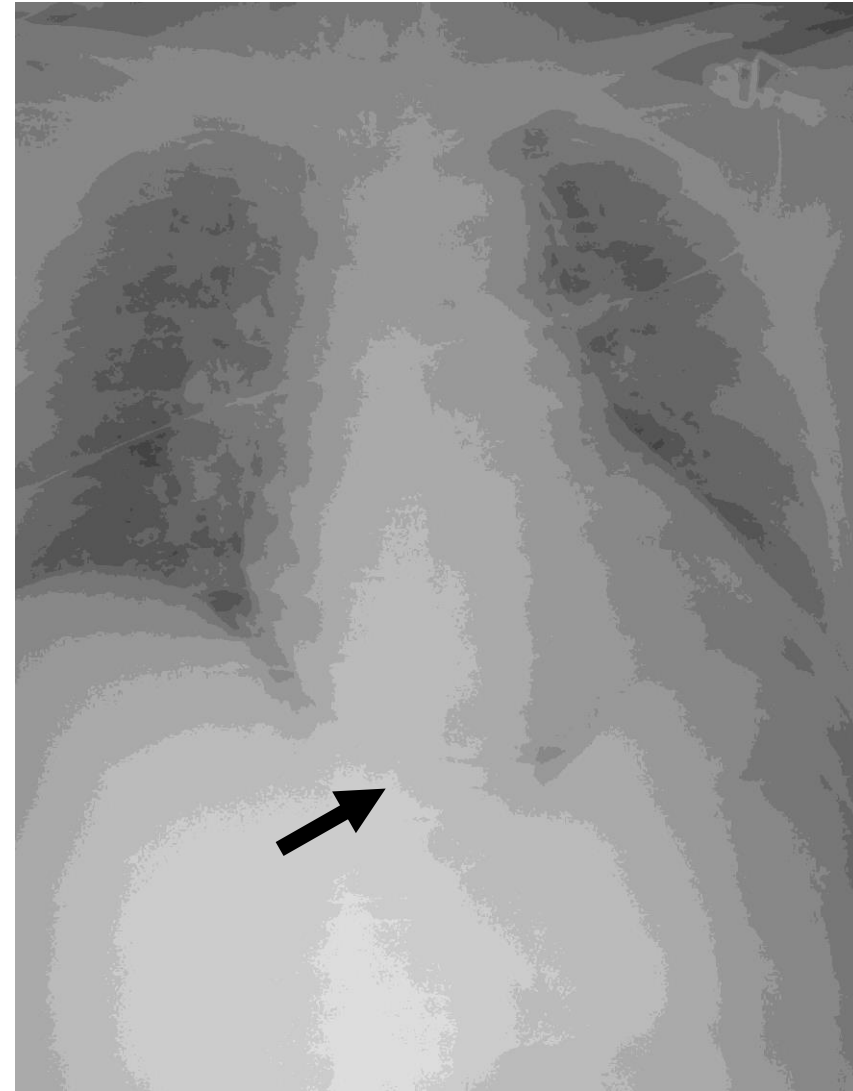
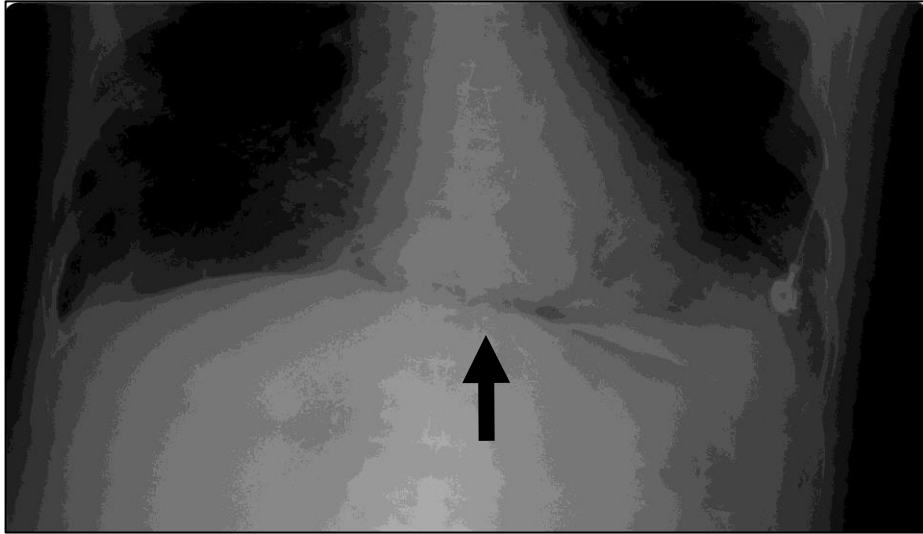


Supine

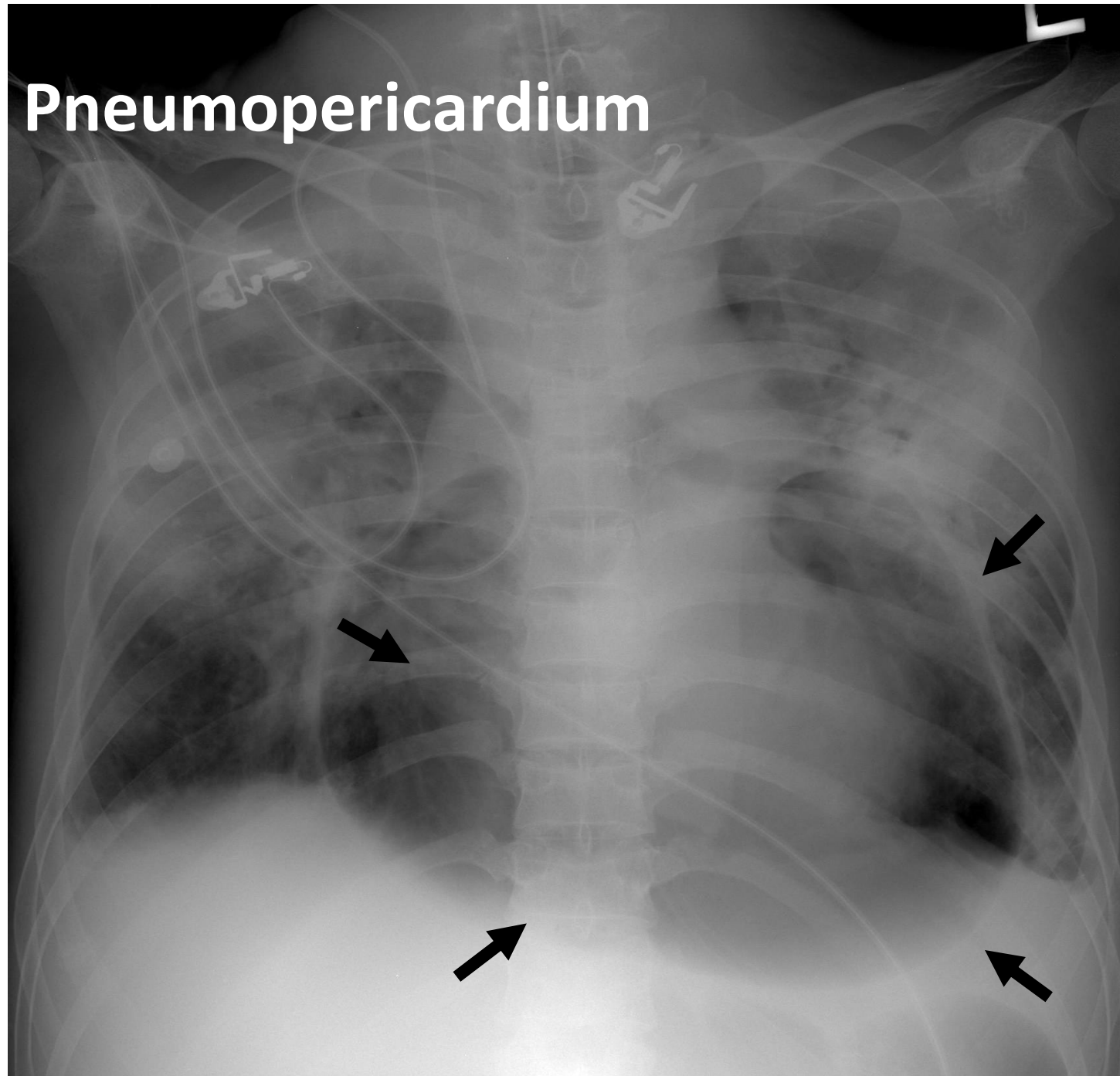


Sit

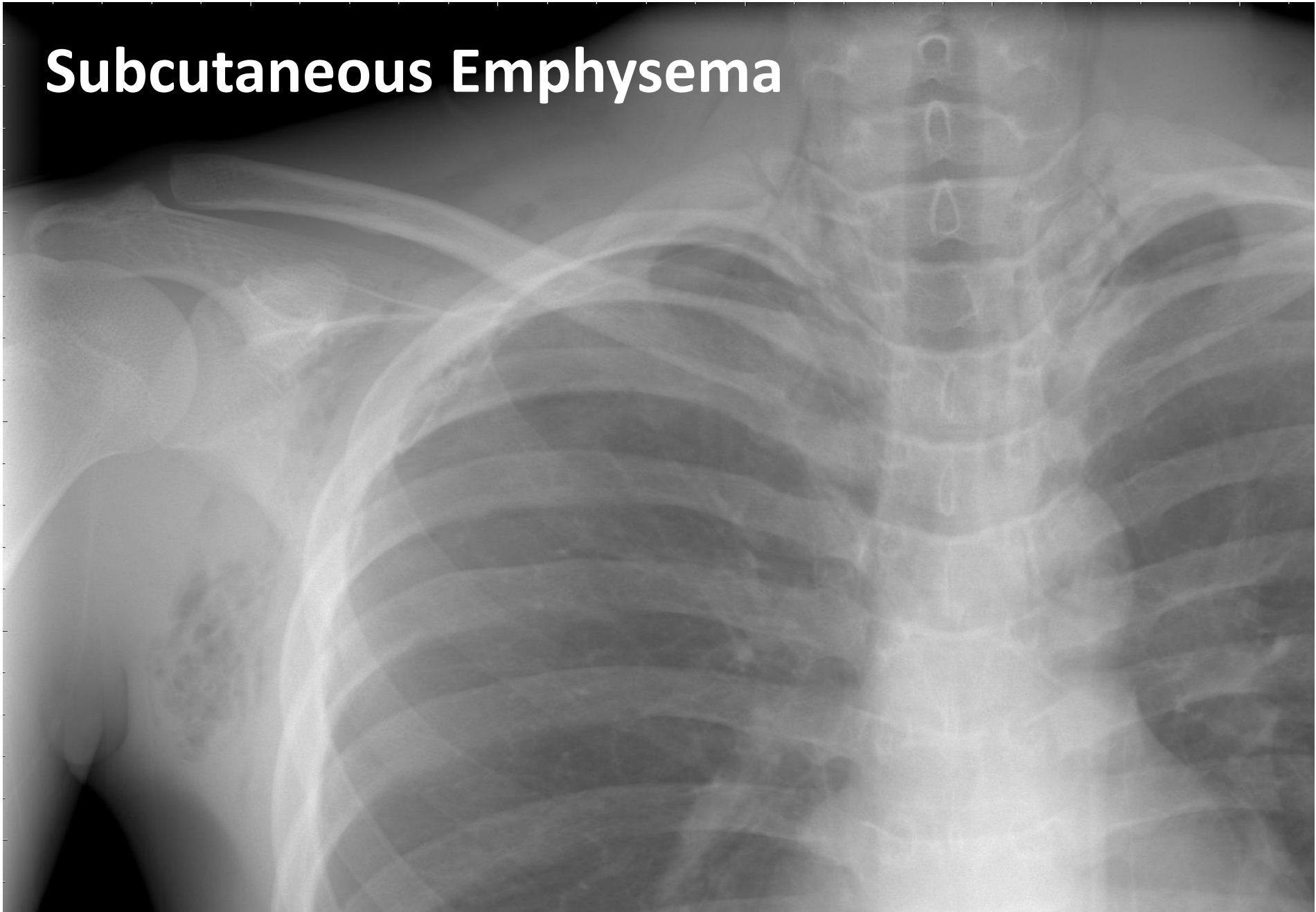




Pneumopericardium



Subcutaneous Emphysema





Pneumoretroperitoneum

L

Pulmonary edema

Cardiogenic pulmonary edema

Non-cardiogenic pulmonary edema (ARDS)

Pulmonary Edema

- **Mechanism:**

- Elevated pulmonary venous pressure
- Increased permeability of alveolar-capillary membrane
- Decreased plasma oncotic pressure
- Lymphatic insufficiency
- Unknown

Pulmonary Edema

- **Cardiogenic:**
- **Noncardiogenic:**
 - Adult Respiratory Distress Syndrome
 - Neurogenic
 - Re-expansion
 - Upper airway obstruction
 - High altitude
 - Drug (Heroin)
 - Hantavirus pulmonary syndrome

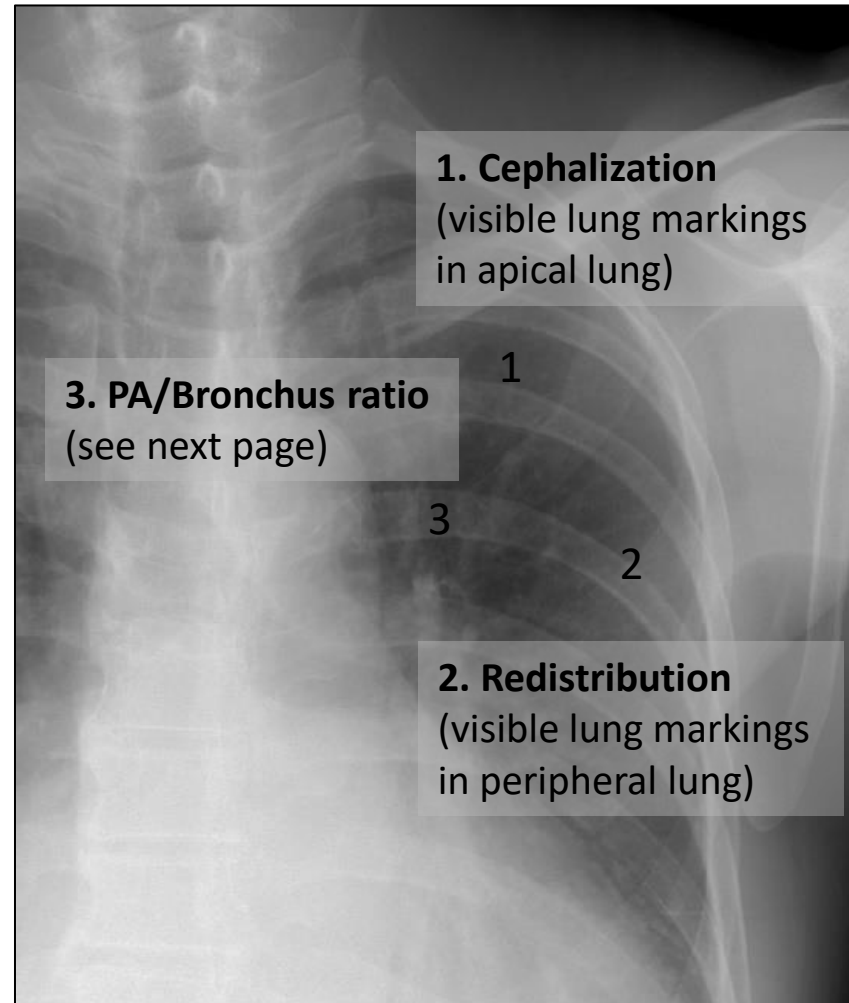
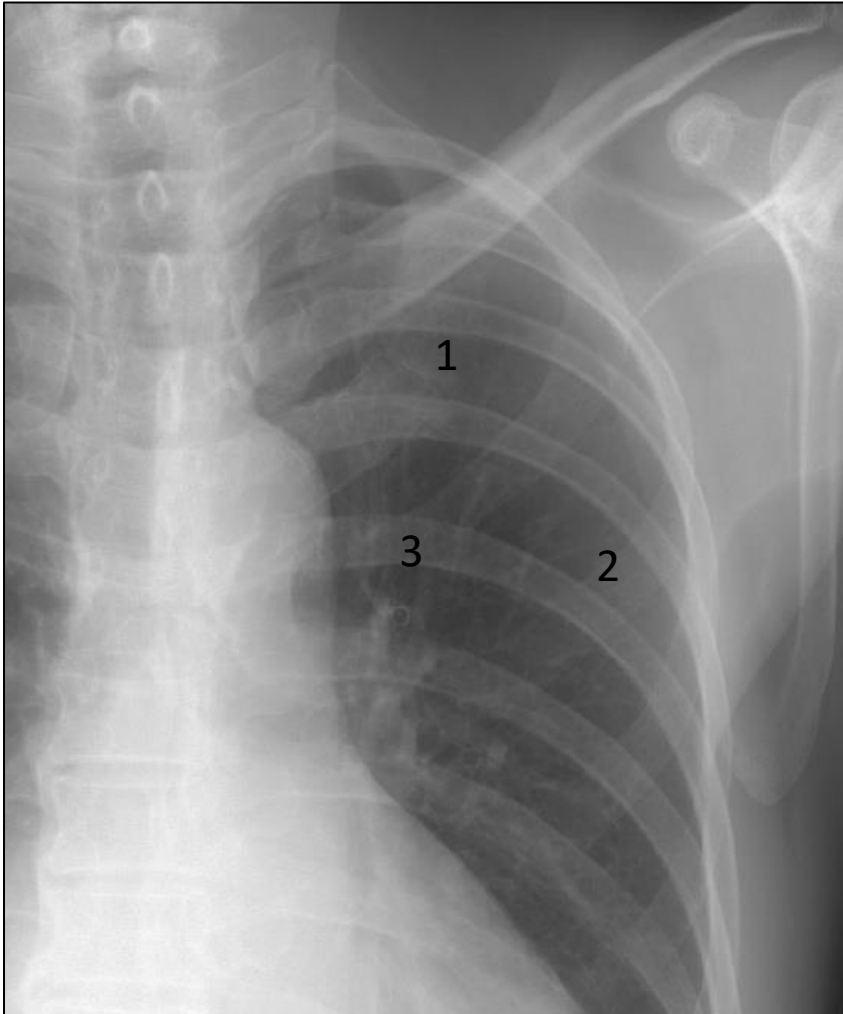
Cardiogenic Pulmonary Edema

- **Increased LVEDP**
 - increased LA pressure
 - increased PV pressure
 - increased PCWP pressure
 - capillary leak
- **Cause of cardiogenic pulmonary edema:**
 - Heart failure: CHF, AMI, VHD...
 - Fluid overload
 - Renal failure

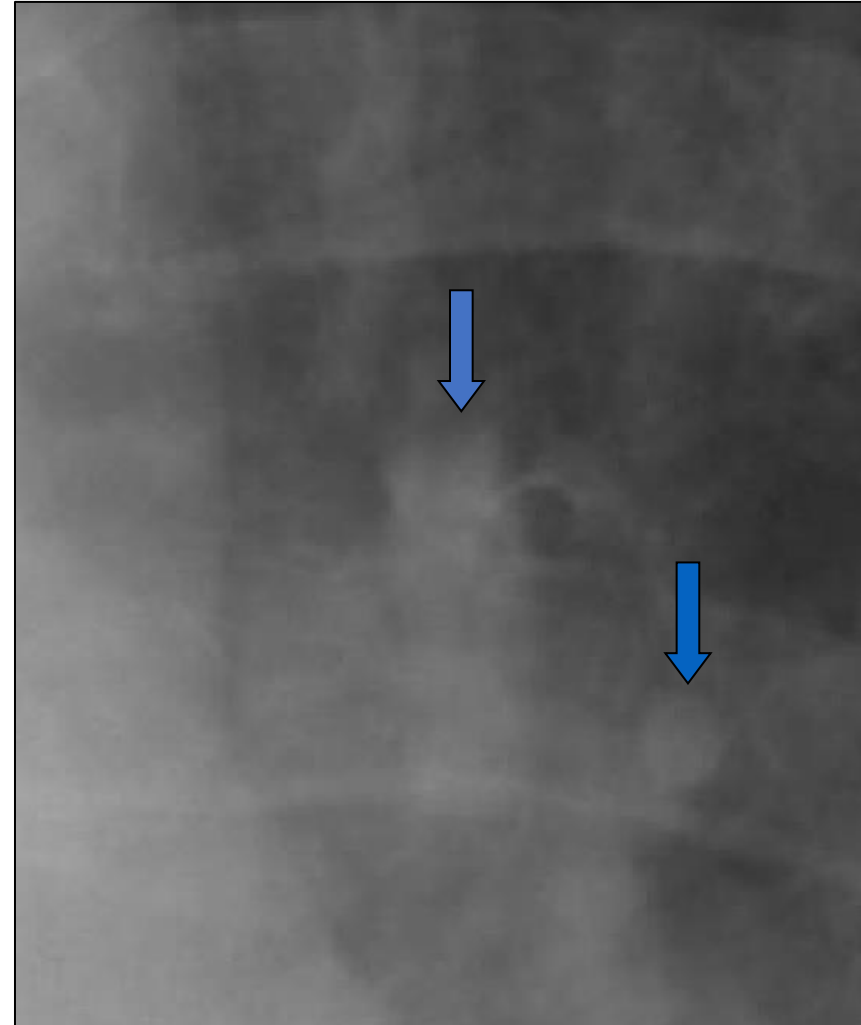
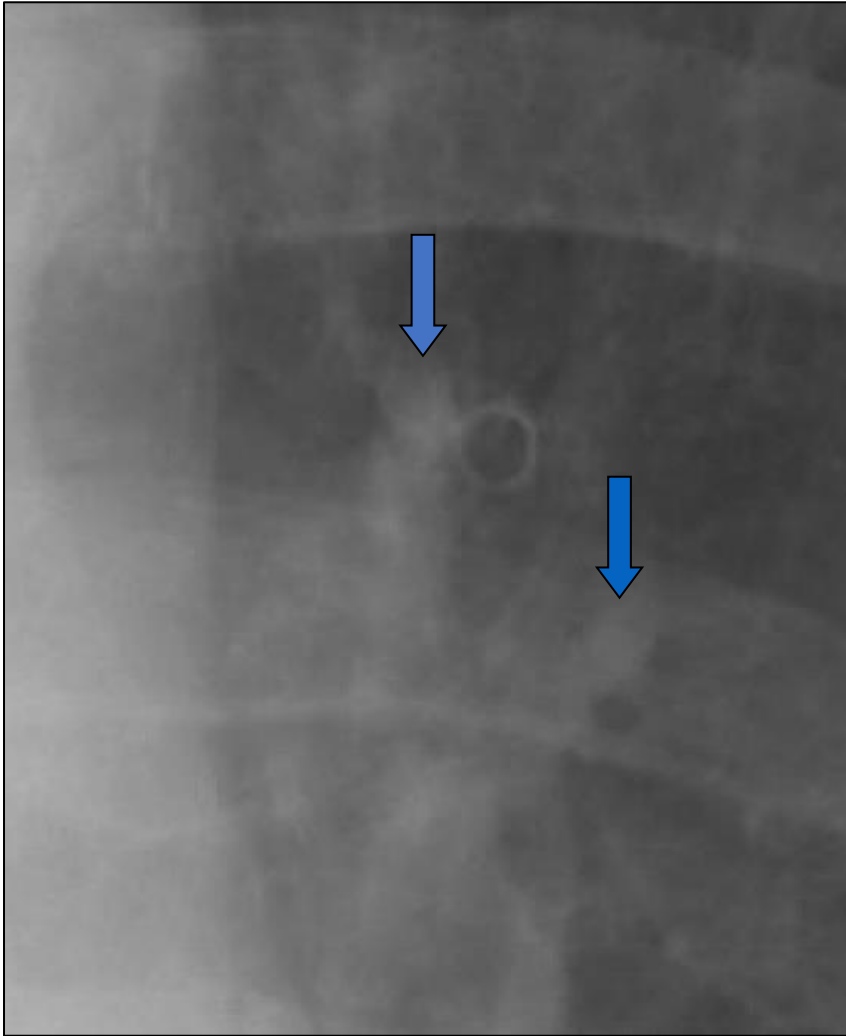
Cardiogenic Pulmonary Edema

- **Signs of raised pulmonary venous pressure:**
 - 正常之站立CXR，下肺野之血管較上肺野之管粗，當肺靜脈壓上昇時，上肺野之血管會與下肺野一樣，甚至更粗。
→ **Redistribution, Cephalization**
 - Vessels in the first intercostal space should not exceed 3 mm in diameter
 - The ratio of PA and bronchus

Vascular Redistribution and Cephalization



Pul Artery / Bronchus



Cardiogenic Pulmonary Edema

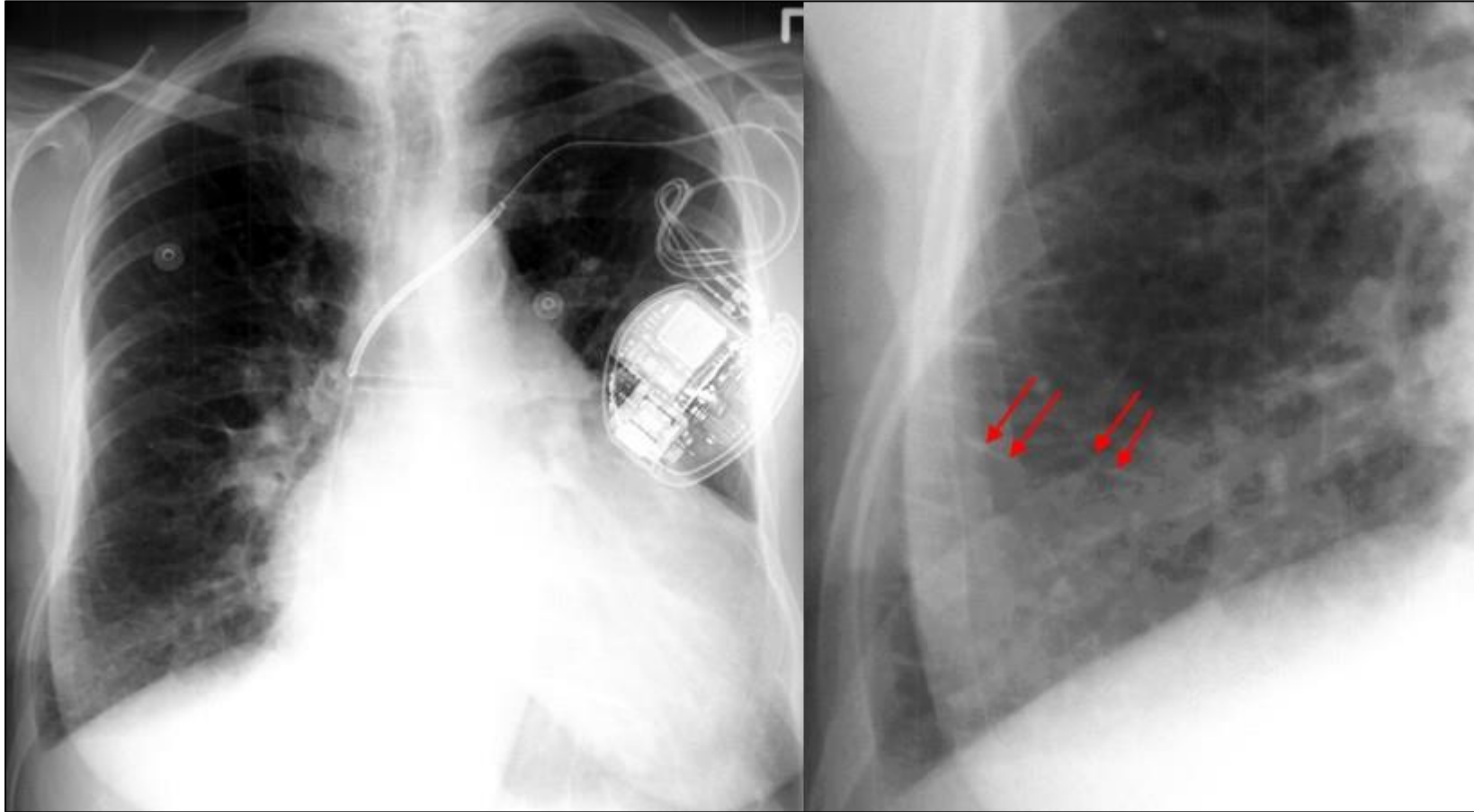
- Normally, the pulmonary interstitium and alveoli are relatively dry.
- Increased pulmonary venous pressure → increased interstitial fluid → increase lymphatic drainage
- Once the capacity of lymphatic drainage is exceeded, **interstitial edema** results. When fluid spills into the air space, **alveolar edema** results.

Interstitial Pulmonary Edema

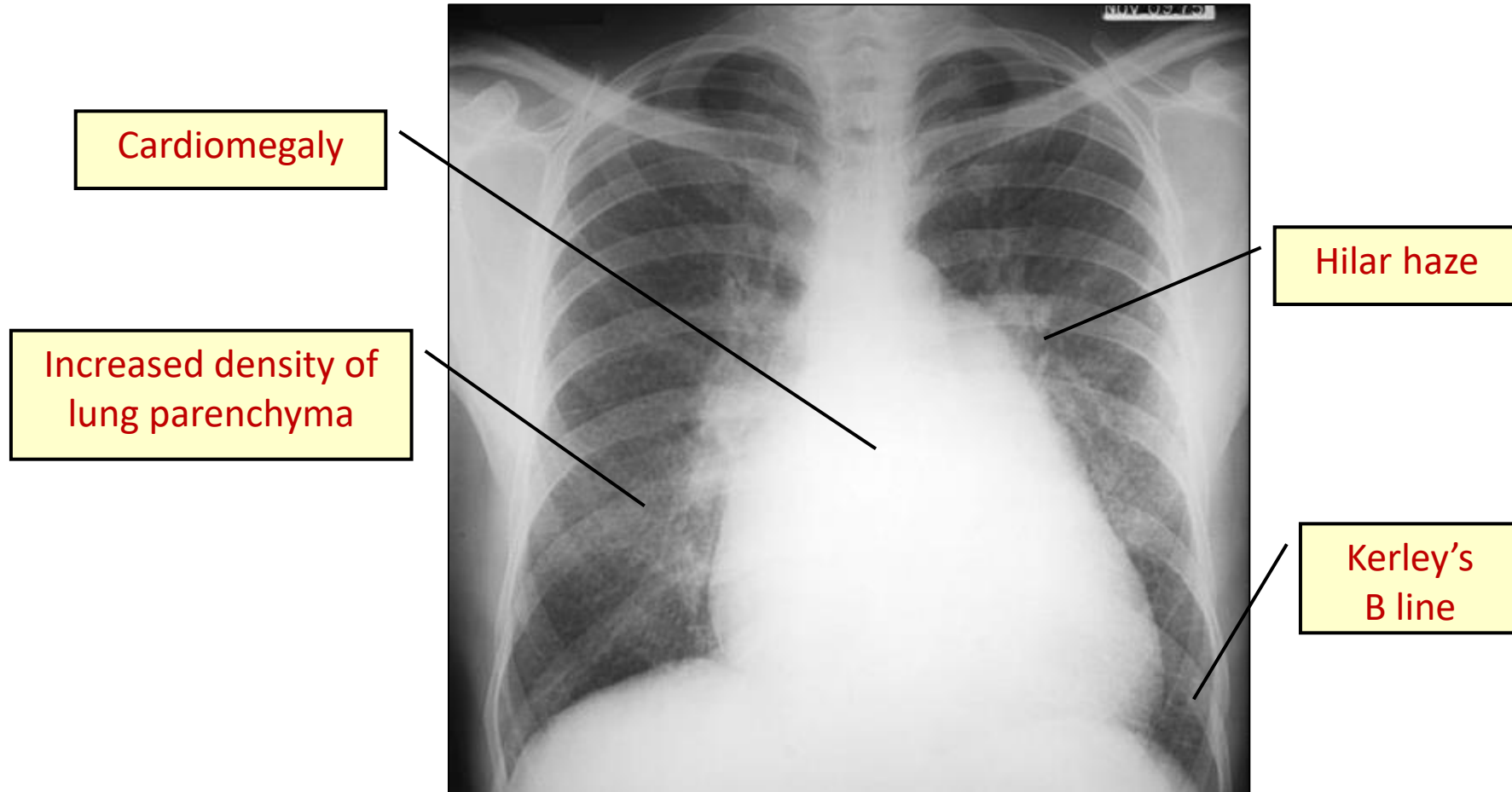
- Septal lines: Kerley's A line, Kerley's B line
- Bronchial wall thickening (peribronchial cuffing)
- Interlobar septal thickening
- Pleural effusion
- Hilar haze: loss of definition of large pulmonary vessels
- Diffuse reticular pattern resembling interstitial fibrosis
- Increased density of the lung parenchyma
- Enlarged mediastinal LN and mediastinal fat opacification

Interstitial Pulmonary Edema

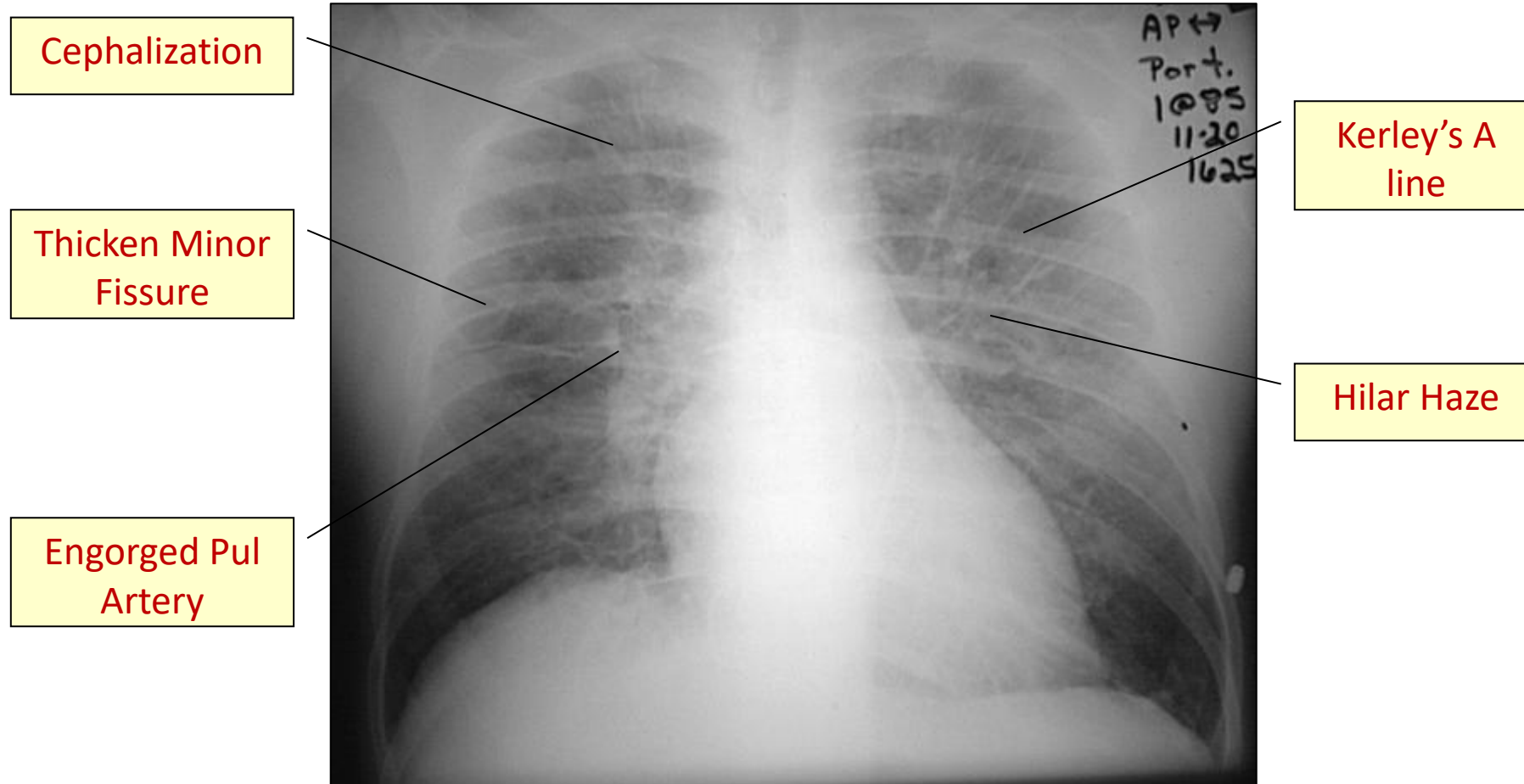
Septal Lines: Kerley's B Lines



Interstitial Pulmonary Edema



Interstitial Pulmonary Edema



Alveolar Pulmonary Edema

- **Air-space filling**

- ill-defined, tends to coalesce
- Air bronchograms or air alveolograms

- **Distribution**

- Patchy and widespread
- Usually bilateral, occasionally unilateral (R't lung), rarely lobar (MR→RUL)
- Central or Perihilar distribution: “Bat’s wing” or “Butterfly” pattern.

Alveolar Pulmonary Edema

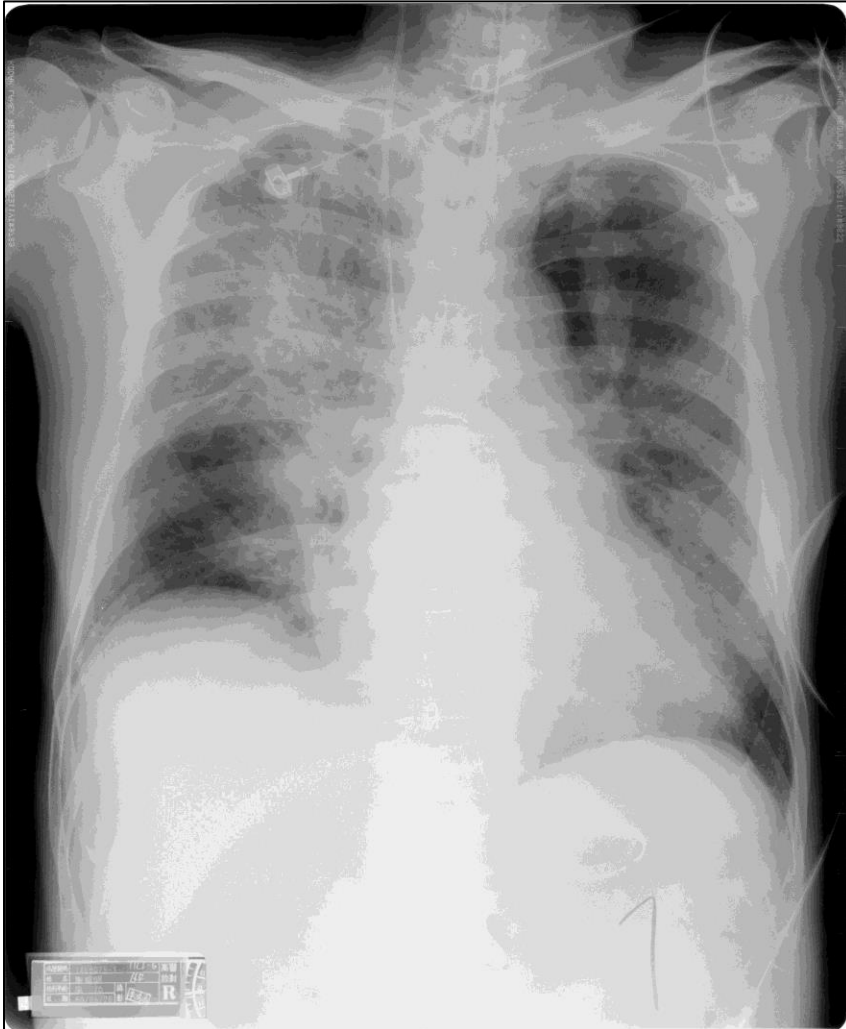


- **Butterfly pattern:**

- Perihilar distribution of air-space filling, leaving an aerated outer “cortex”.
- 此雖為心因性肺水腫之典型表現，但並不十分常見。多數患者之CXR呈現更為瀰漫且不規則之分佈，某些肺葉顯得較為嚴重。

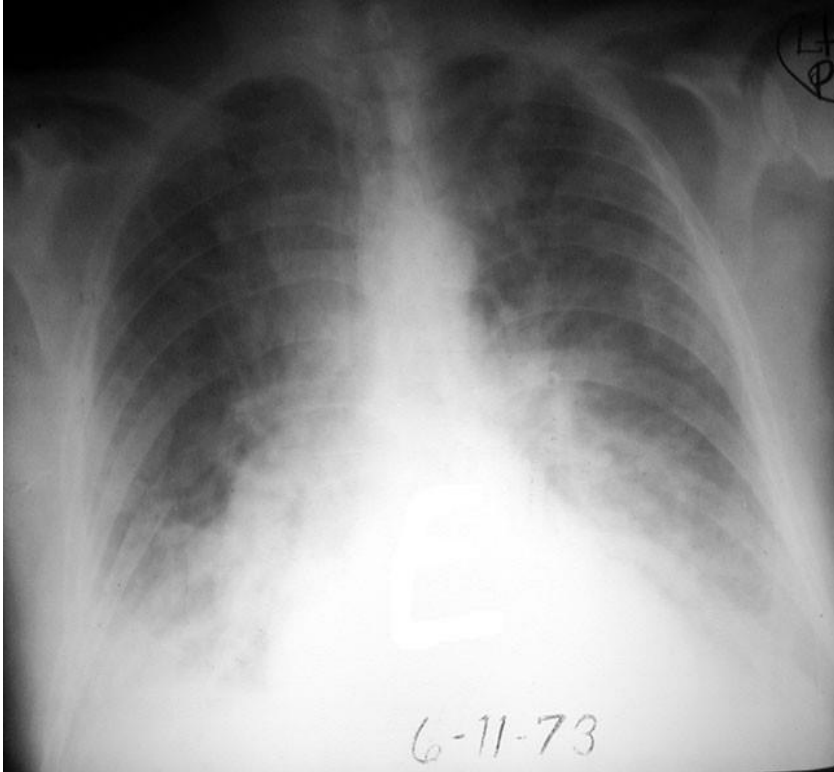
← A case of AMI with Acute MR

Alveolar Pulmonary Edema



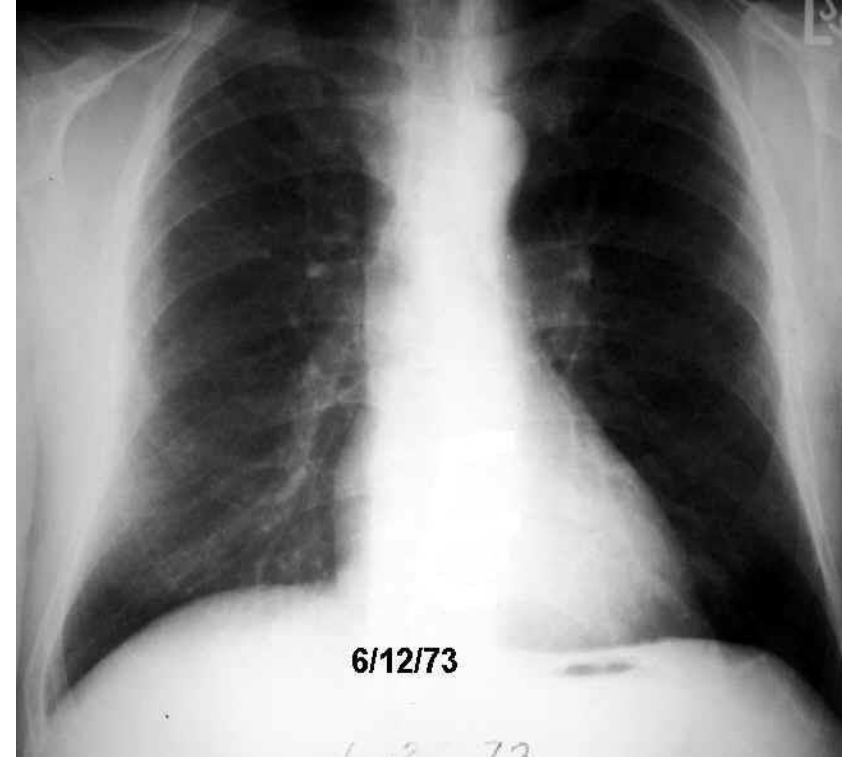
- **Rapid change on films over short intervals**
- **Change of distribution several hours after patients change their position**
- **Rapid clearing suggest cardiogenic pulmonary edema**

**Uremia
HD**



**Interstitial and alveolar edema
Bilateral pleural effusion**

After



One day later

Cardiogenic Pulmonary Edema



- 擴張之肺動脈
- 血管紋增加
- 肺門周圍陰影(haze)
- 增厚之肺葉間裂



- 傾頭性(cephalization)
- 支氣管周圍 Cuffing
- Kerley B及A線
- 肋膜滲出液



- 肺底水腫
- 肋膜滲出液
- 肺門周圍腫



- 不清楚之肺低血管
- 低肺體積

Interstitial edema

Alveolar edema

Non-cardiogenic Pulmonary Edema

Acute Respiratory Distress Syndrome (ARDS)

Diagnostic Criteria (1994 AECC Definition):

1. Acute onset

usually within 24 hours, most within 72 hours

2. Bilateral infiltrates on CXR

3. $\text{PaO}_2/\text{FiO}_2$ of 200 or less

$\text{PaO}_2/\text{FiO}_2$ of 300 or less → Acute Lung Injury (ALI)

4. PCWP of 18 mmHg or less, or no clinical signs of left atrial hypertension

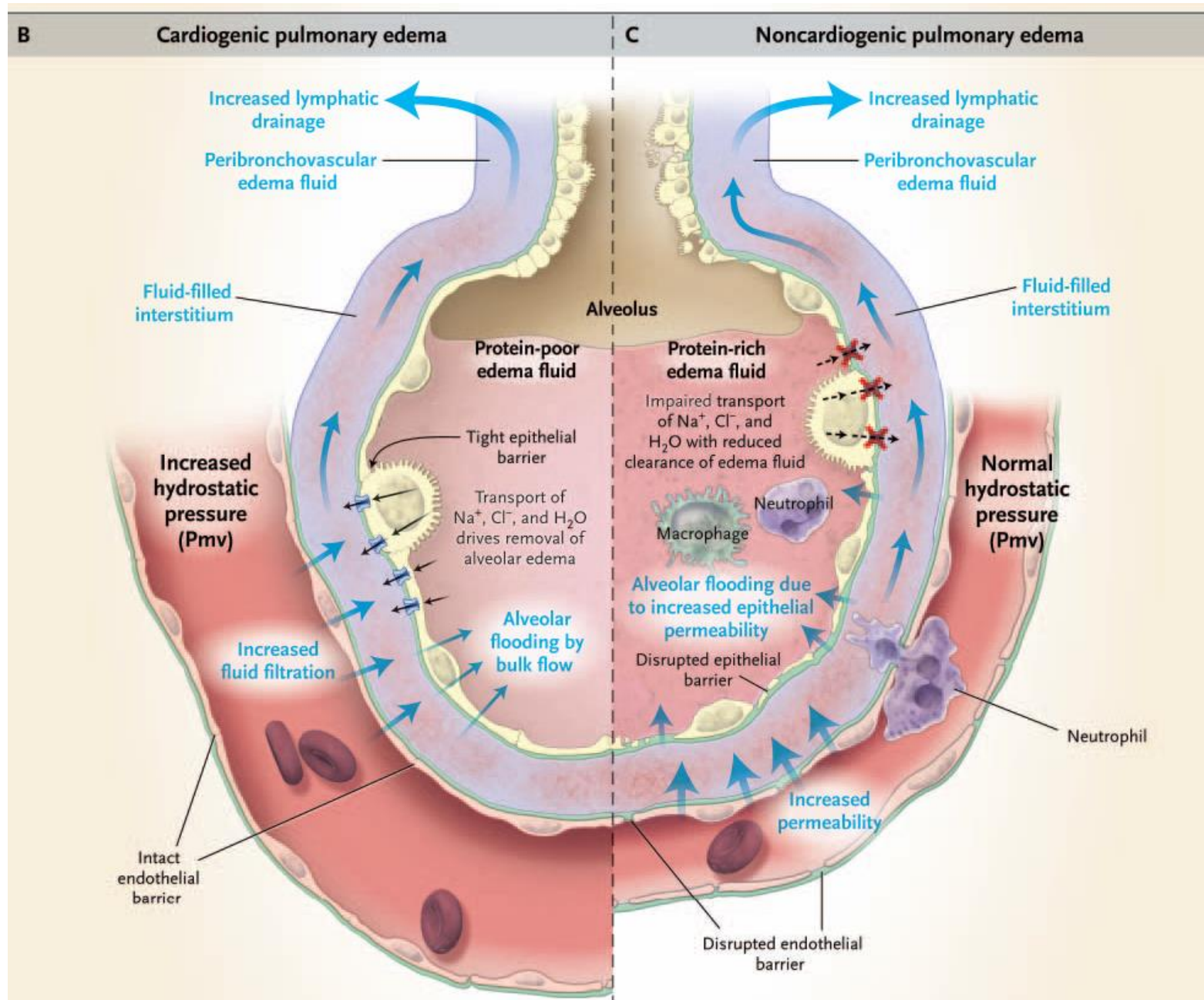
No clinical evidence of fluid overload or cardiogenic pulmonary edema

Non-cardiogenic Pulmonary Edema

Acute Respiratory Distress Syndrome (ARDS)

Diagnostic Criteria (2012 Berlin Definition):

1. 急性發生 (於七日內)
2. 胸腔影像呈現兩側肺部不透明
3. 無法由心衰竭或體液過多解釋的肺水腫
4. 氧合不佳 (在CPAP或PEEP ≥ 5 cm H₂O下 P/F ratio ≤ 300)
 - P/F 200-300 $\rightarrow$ Mild ARDS
 - P/F 100-200 $\rightarrow$ Moderate ARDS
 - P/F < 100 $\rightarrow$ Severe ARDS



CXR of ARDS

- Bilateral, widespread, patchy, ill-defined air-space filling.
- Usually all lung zone are involved both centrally and peripherally.
- Signs of interstitial edema may also be present, but septal lines are rare.

CT Scan of ARDS

- Heterogenous
- Air-space consolidation and ground-glass opacity
- The densely consolidated lung tends to locate on the dependent site
- Interstitial thickening, fibrosis in late stage
- Cyst or bullae formation
- Bilateral pleural effusion

Exudative Phase

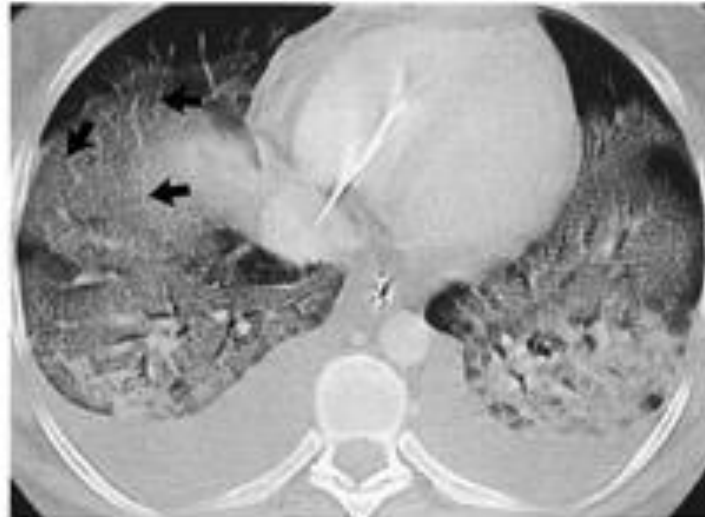


A

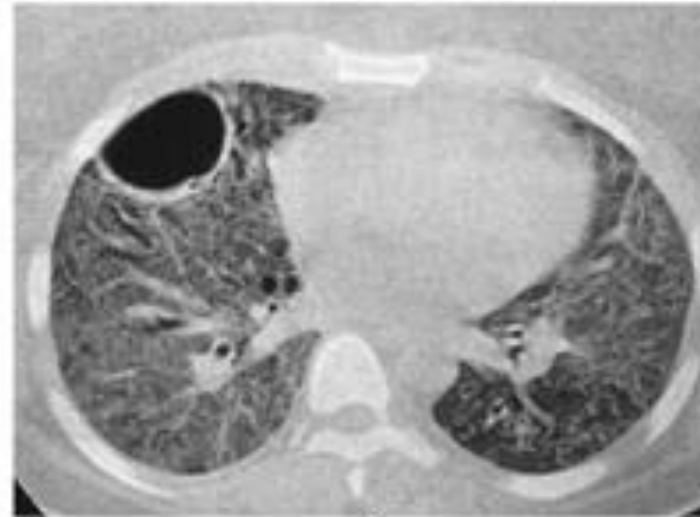
Fibrosing-alveolitis Phase



B



C

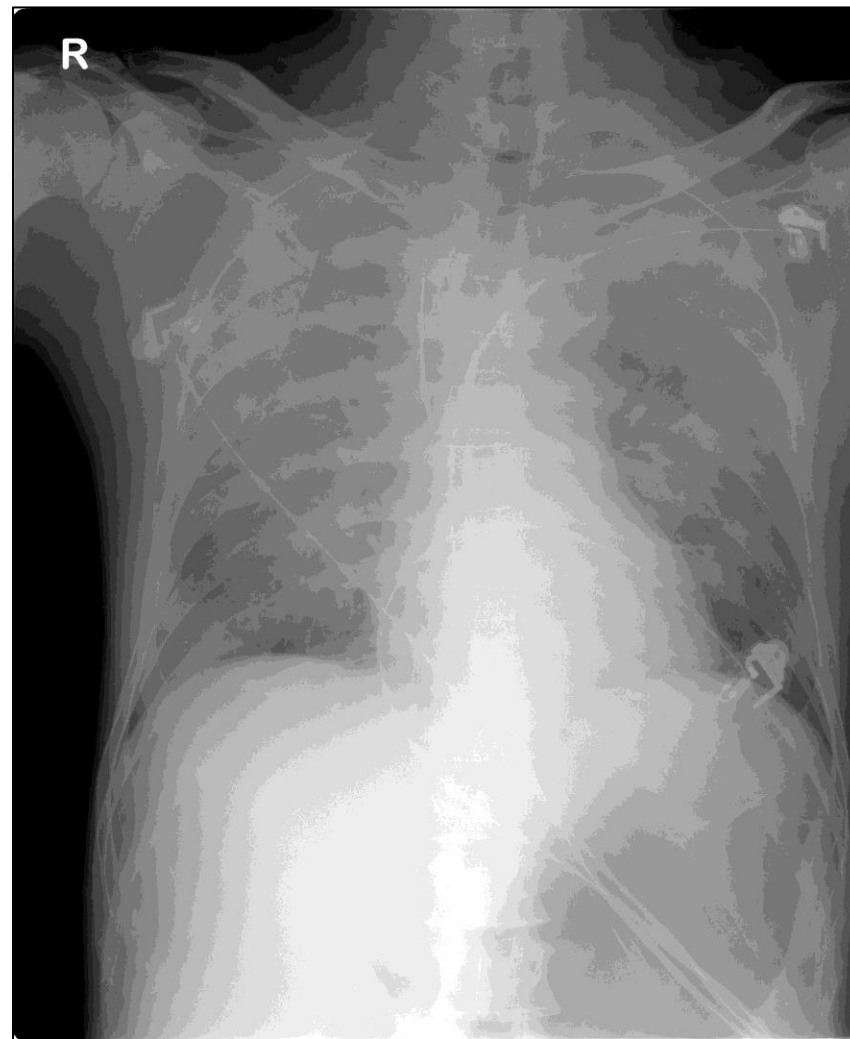
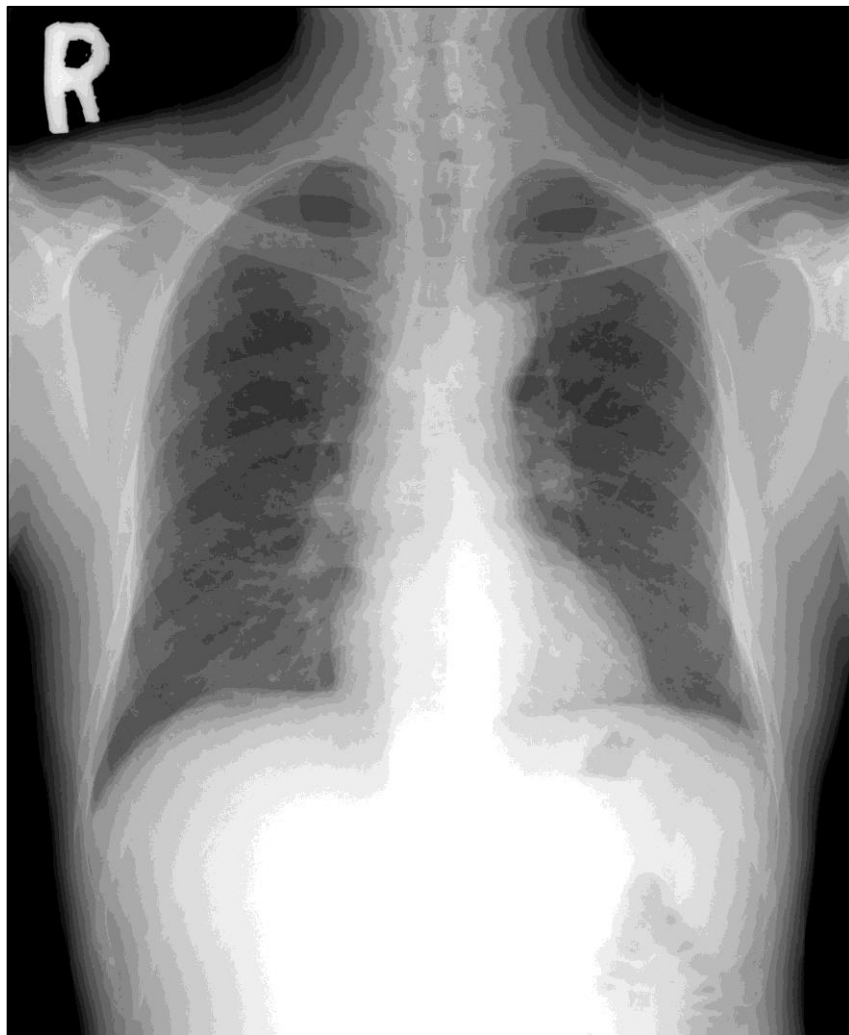


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Ware LB et al, NEJM, 2000

Sepsis-induced ARDS

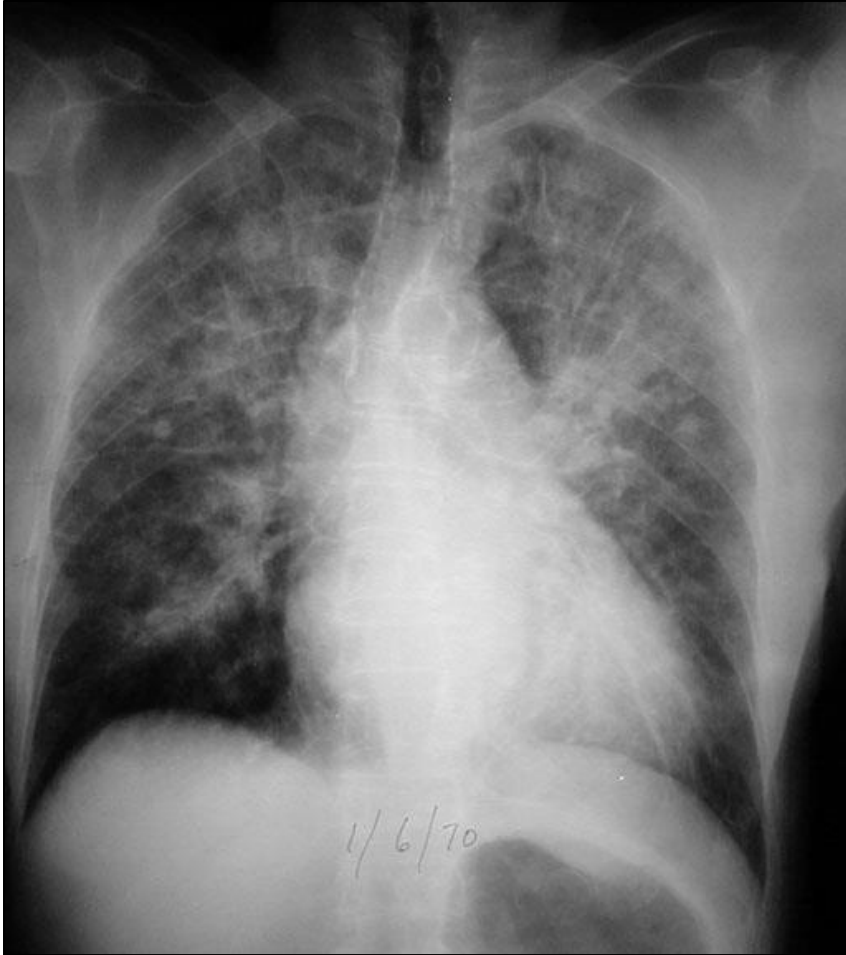
A case of *Vibrio* infection



Paraquat Intoxication



Neurogenic Pulmonary Edema



- 多發生於Head injury、ICH、Seizure、Brain tumors之病人。
- Mechanism: unknown
可能由於交感神經突然過度興奮，導致肺血流量增加，肺靜脈壓上昇。另外endothelial damage亦有其角色。
- The heart is not enlarged.
- Can occur in a minute. The lung usually clear within 24 to 48 hours

CXR: Cardiogenic pulmonary edema vs. ARDS

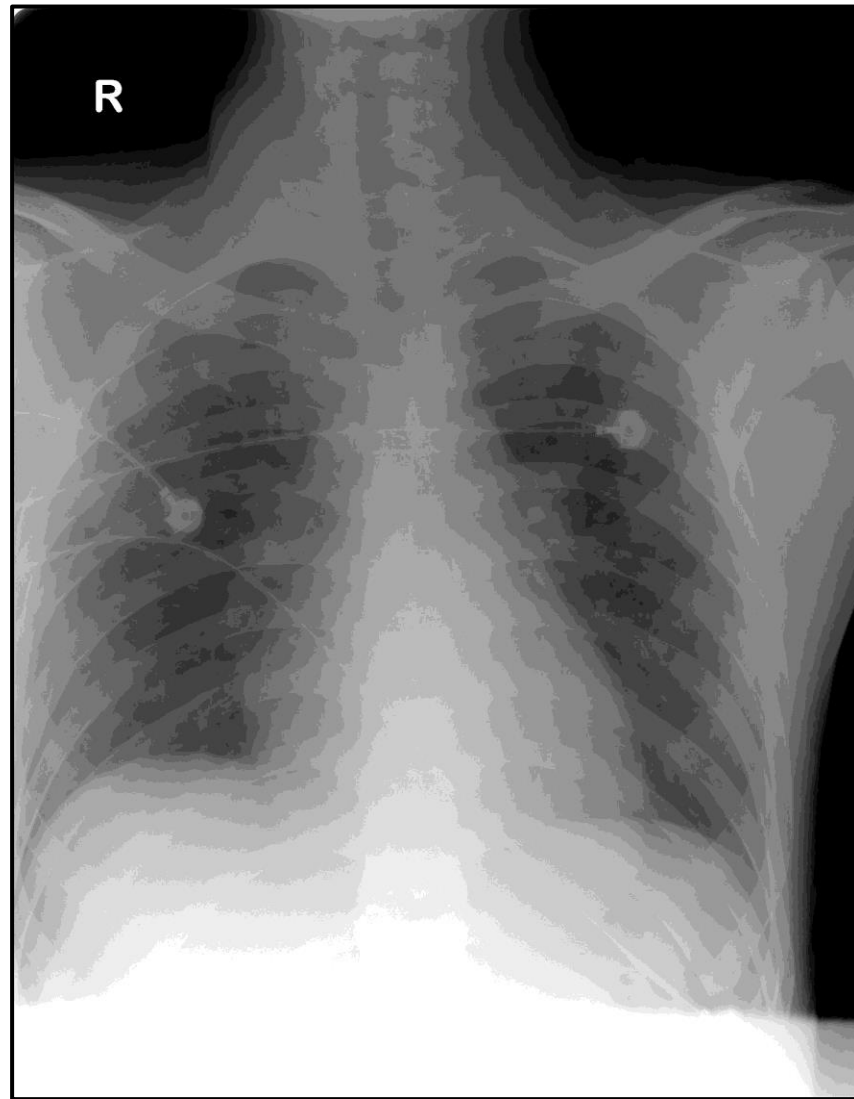
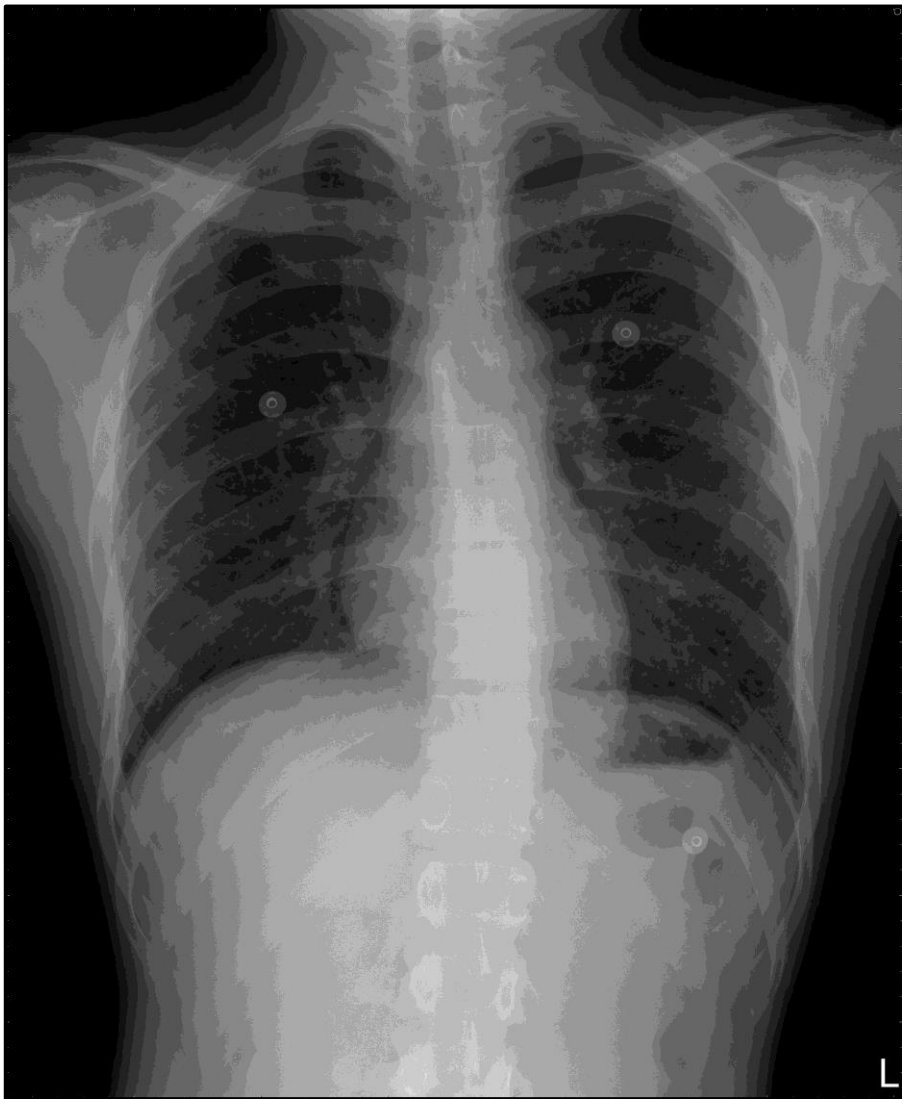
	Cardiogenic Pulmonary Edema	ARDS
CXR之表現	較症狀早或同時發生	較症狀晚出現
Change on serial CXR	Rapid	Slow
Distribution	Central distribution, Peripheral sparing	More diffuse, both centrally & peripherally
Cardiomegaly, Cephalization	常見	較少見
Septal lines, Peribronchial Cuffing	常見	少見
Air bronchograms	少見	常見
Pleural effusion	量多	量少

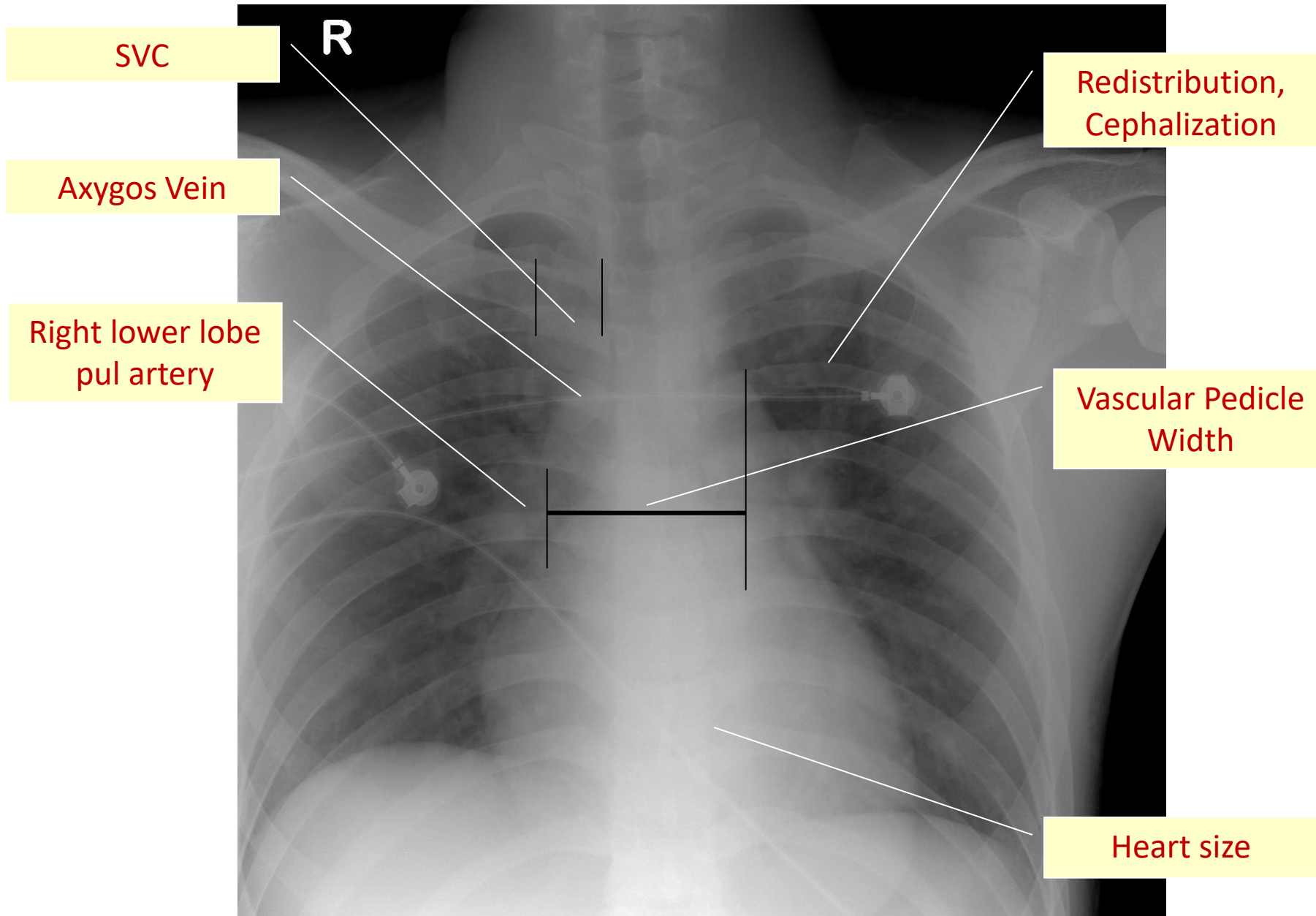
Fluid Status Evaluation

Evaluation of Fluid Status on CXR

- Signs of increased pulmonary venous pressure
- Signs of interstitial edema
- Signs of alveolar edema
- Heart size
- SVC and Azygos vein
- Vascular Pedicle Width (VPW)

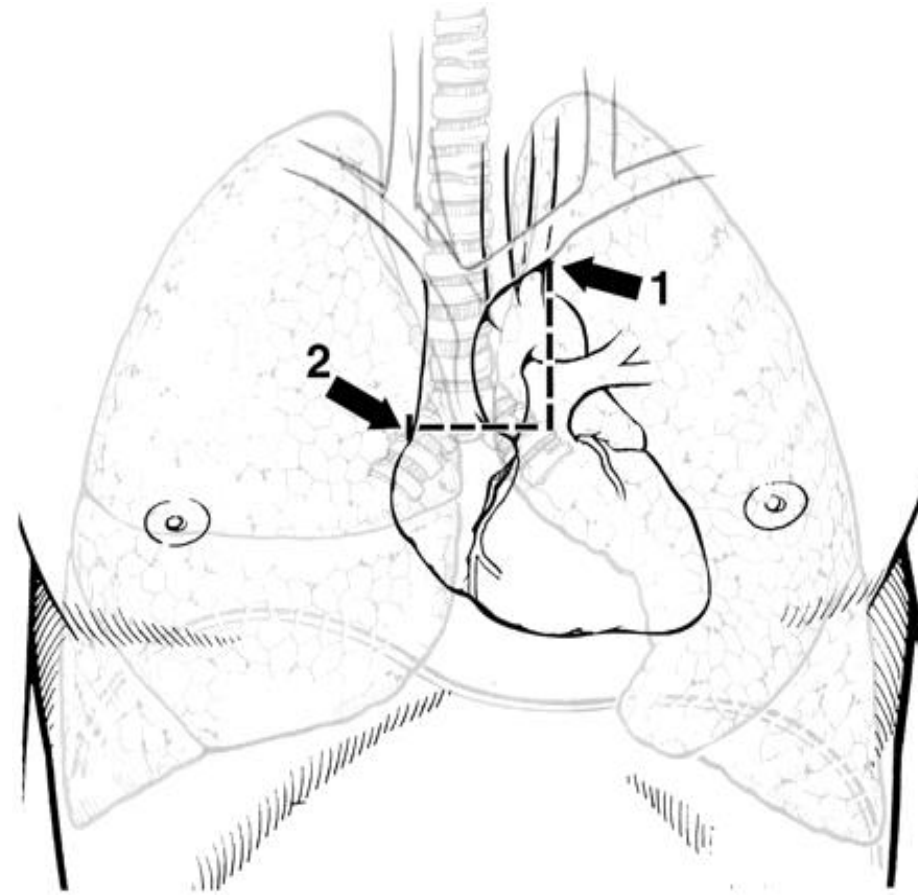
**3 days later, after fluid
resuscitation of 8000 ml**



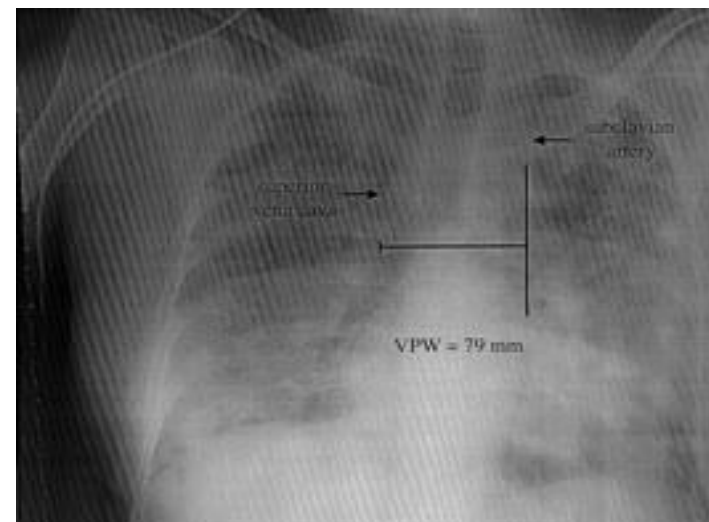
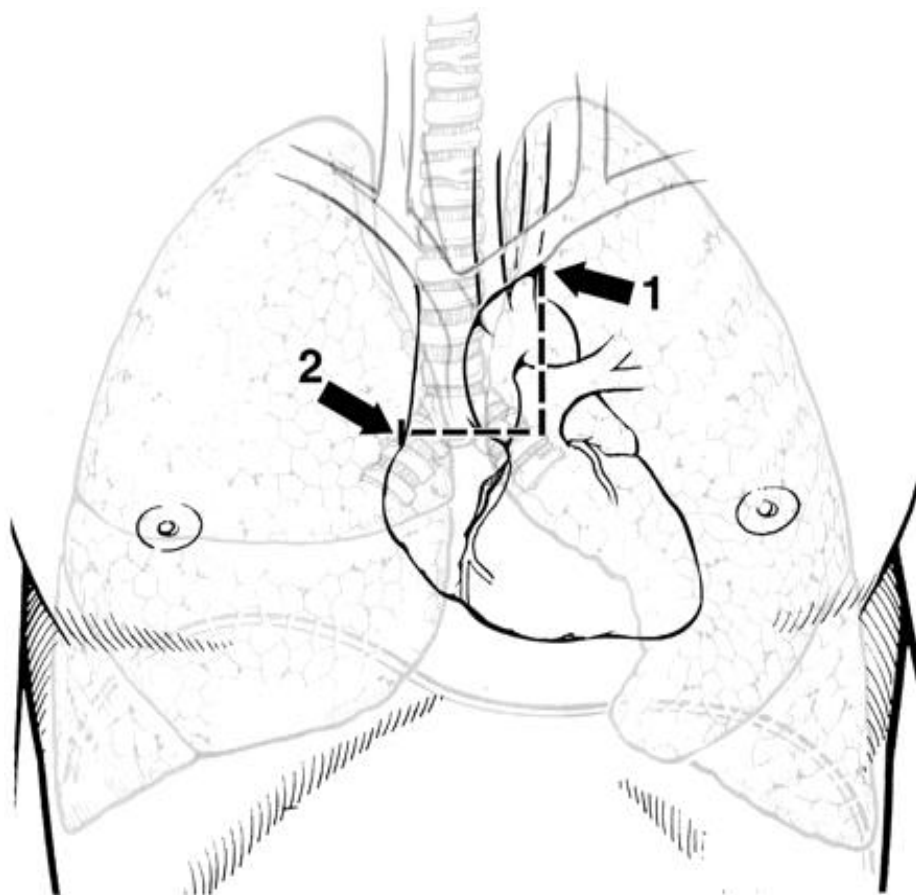


Vascular Pedicle Width

1. Aortic arch上left subclavian artery出口處劃下垂直線
 2. SVC與right main bronchus之交界
- 正常upright CXR 之 VPW = 48 ± 5 mm
 - CTR > 55%且VPW > 70 mm 較正常時有三倍以上之機會PCWP > 18 mmHg



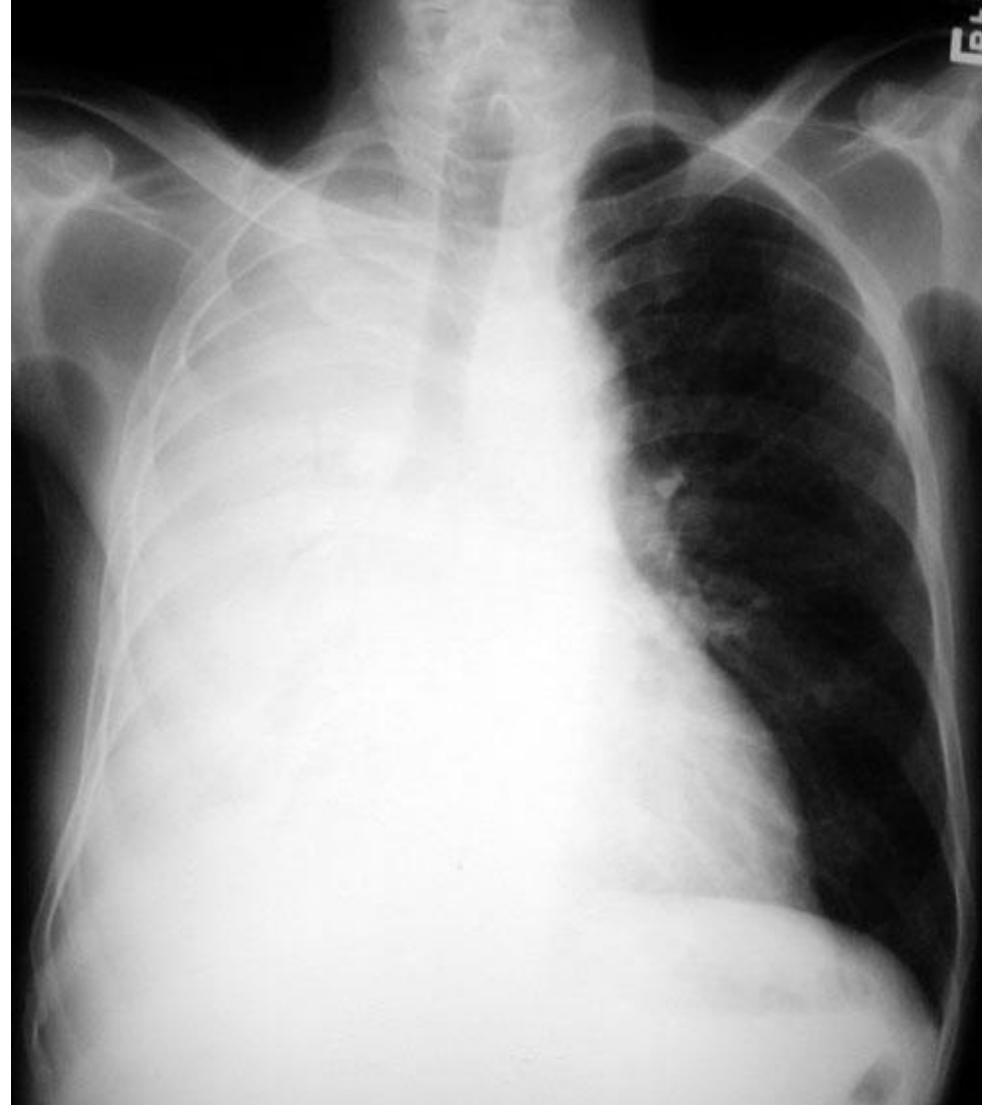
Vascular Pedicle Width



Atelectasis

- Direct sign: collapsed lung
- Indirect sign: volume reduction
 - Trachea, heart, hilum, fissure, diaphragm, intercostal space

Right Lung Collapse



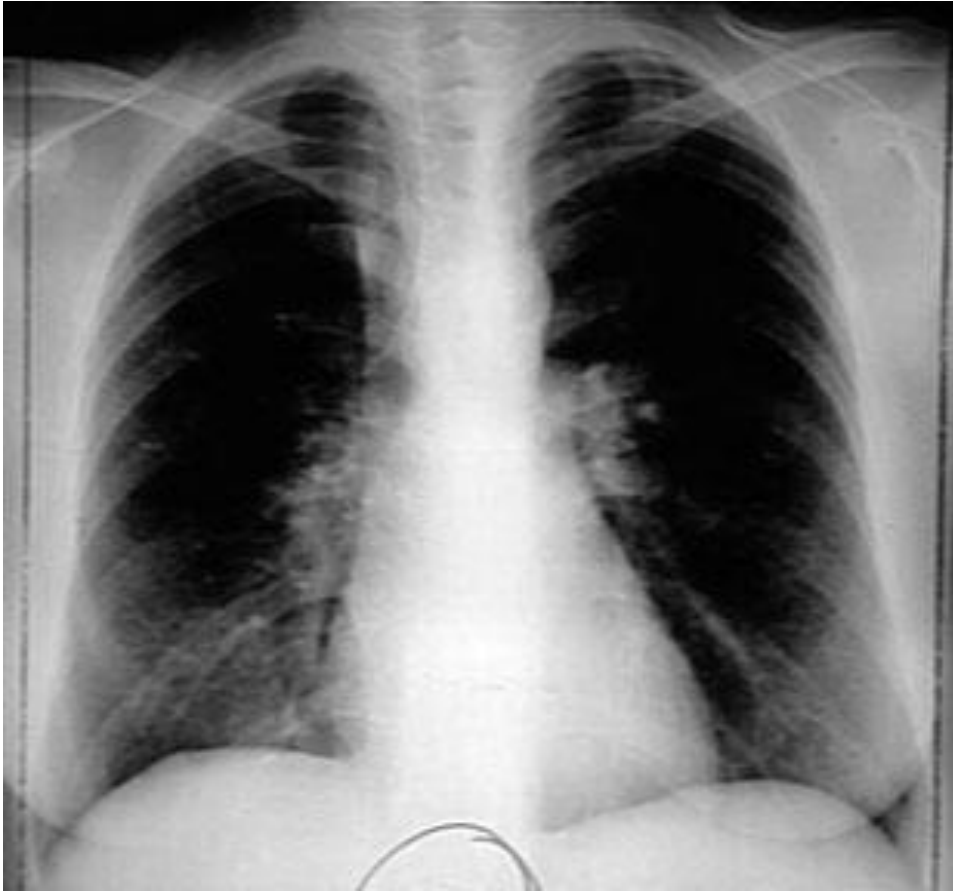
Left Lung Collapse



RUL Collapse



RML Collapse



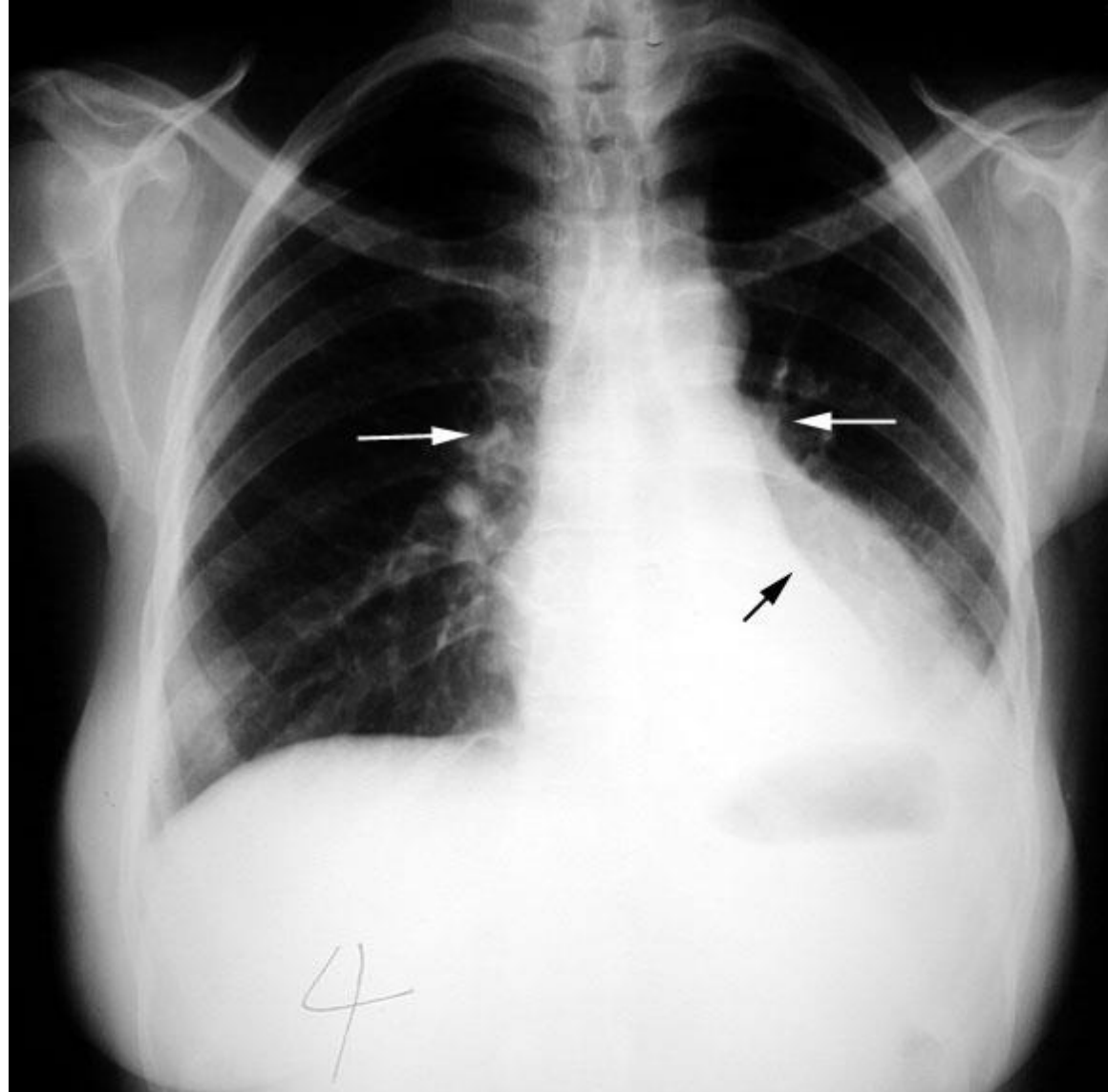
RLL Collapse



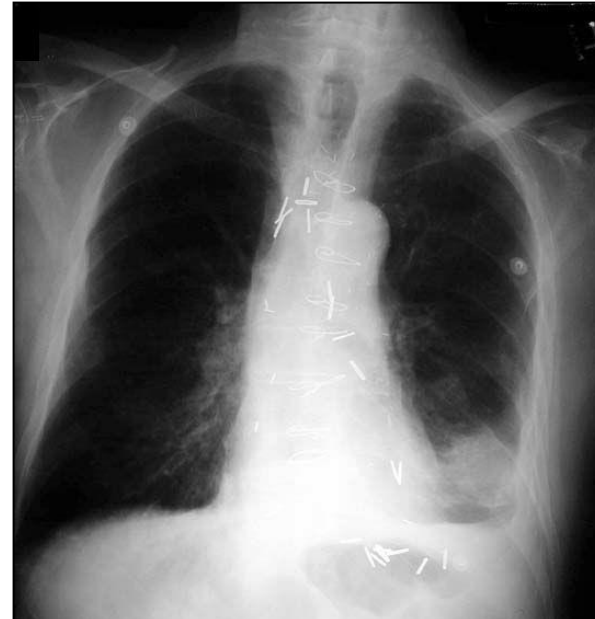
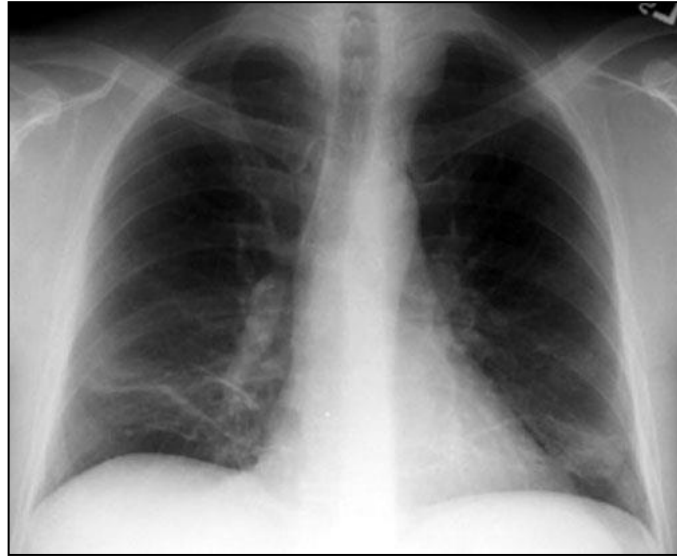
LUL Collapse



LLL Collapse



Segmental or Subsegmental Atelectasis



Pulmonary Embolism

*All the signs of PE have poor sensitivity and specificity.
The major role of CXR is to exclude other diagnoses.*

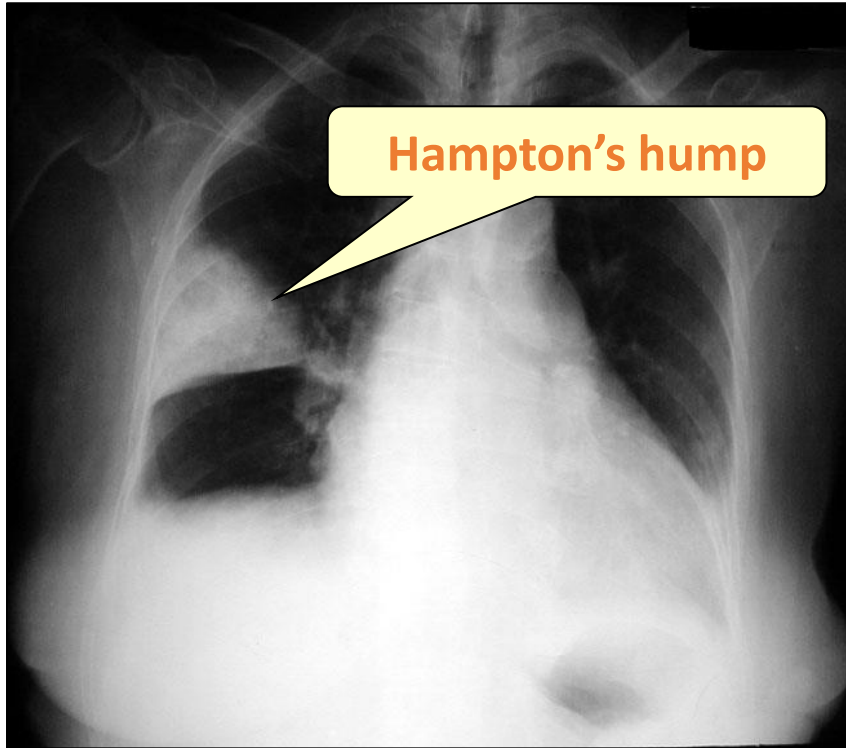
CXR of Pulmonary Embolism

- Normal
- Westermarck's sign:
 - Oligemia of the lung beyond the occluded vessel
- Hampton's hump:
 - pleural-based, wedge-shape air-space consolidation. Caused by pulmonary hemorrhage or infarction.
- Signs of right heart failure:
 - cardiomegaly, engorged PA
- Pleural effusion:
 - 50%, small amount, unilateral, transudate or exudate, may be bloody.



Westermark's Sign
Marked decreased vascularity

Pulmonary Infarction



- It takes several months to resolve
- Frequently leaves permanent linear scar
- Cavitation is rare

Thank for your attention