Don't Blink: Plain Film Diagnoses You Cannot Afford to Miss

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Objectives

- Identify the ten most important, life-threatening plain film diagnoses that must not be missed in critical patients.
- Understanding the roles of portable CXR at ED and ICU
- Interpret the radiographic findings that indicate these diagnoses.
- Review confirmatory studies required to secure a diagnosis in these cases.

ICU Chest X-Ray

- Mode of respiration /ventilation and lung volumes
- Placement of intravascular catheters, tubes, and drains
- Barotrauma
- Extravascular and intravascular fluid status
- Progression / regression of known cardiopulmonary disease

Mobile Radiography

- Exposure Time
  - Relative long
  - Loss of edge detail, unsharpness due to patient motion
  - Vascular margins indistinct
    - DDx: interstitial edema

Mobile Radiography

- Patient positioning
  - Caudal / cranial beam angulation relative to the film cassette
    - Apparent diaphragm elevation
    - Effacement of the hemi-diaphragm contour
  - Standard source-to-image receptor distance should be used to compare cardiac and vascular dimensions with a series of films

Mobile X-Ray Unit

- Lower kV(p), 80 –90; standard: 120 – 140 kV (p)
- No grid, more scattered ray , more blurred image
- Use of Computed Radiography (CR)
  - Lower dose. Better contrast
  - Digital optimization of the image quality

Evolution of Radiography

- Conventional Radiography
  - Conventional x-ray imager, film-cassette combination, analogical images
- Computed Radiography
  - Conventional x-ray imager, analogical plates, digital images
- Digital Radiography
  - New digital x-ray imager, digital plates, digital images

Portable DR system

- True filmless system
- Immediate send image by blueteeth to PACS
- Blueteeth system build up in the Medical Buildings
- No recall film
- No time lag

Canon CXDI-60G Portable DR System

Mode of respiration /ventilation and lung volumes

- Whenever possible, exposure at the end of inspiratory phase, facilitating series comparison.
- Increase lung volumes result in “pseudo-resolution” of air-space consolidation
- Decrease of width of vascular mediastinum

ED real scenarios

Trauma

Acute chest pain

Fever

Dyspnea

Iatrogenesis Imperfecta

Primary Survey

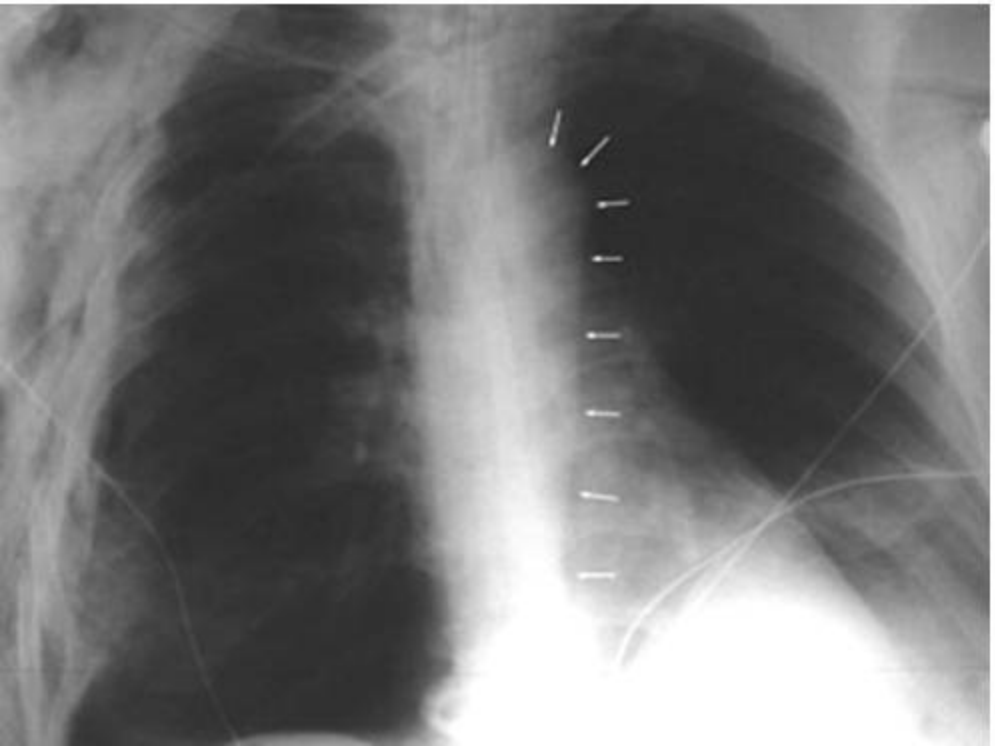
The life-threatening chest injuries

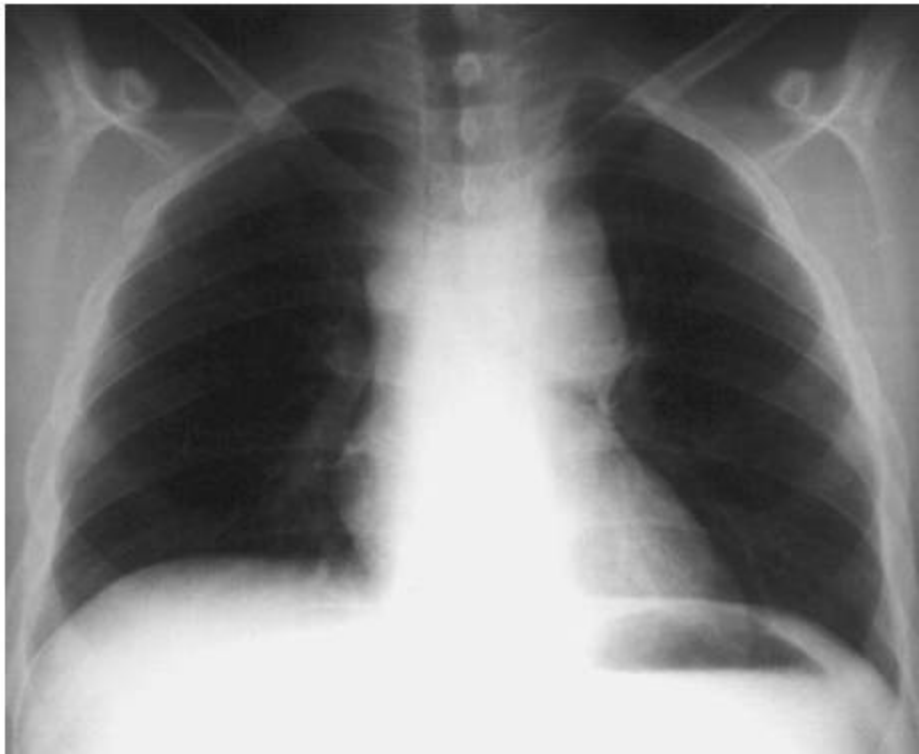
- Tension Pneumothorax
- Massive Haemothorax
- Open Pneumothorax
- Cardiac Tamponade
- Flail chest

Which one do you suspect traumatic aortic injury?

Tips; clear aortic knob and para-aortic stripe, high negative predictive value

Tips: A decceralation injury; may no chest wall injury





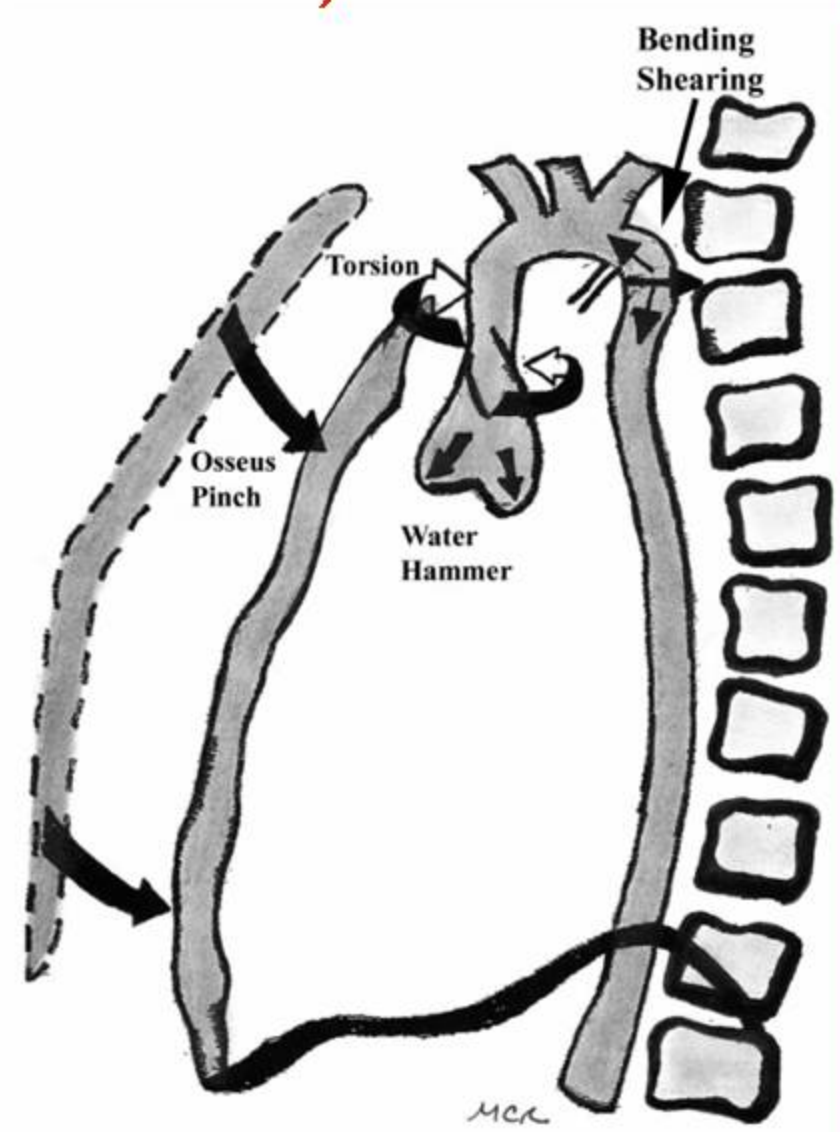
Traumatic aortic injury (Aortic transection)

Definition: traumatic tear of 3 layers
- Complete: 360°
- Incomplete: medial aspect

80% die on the spot

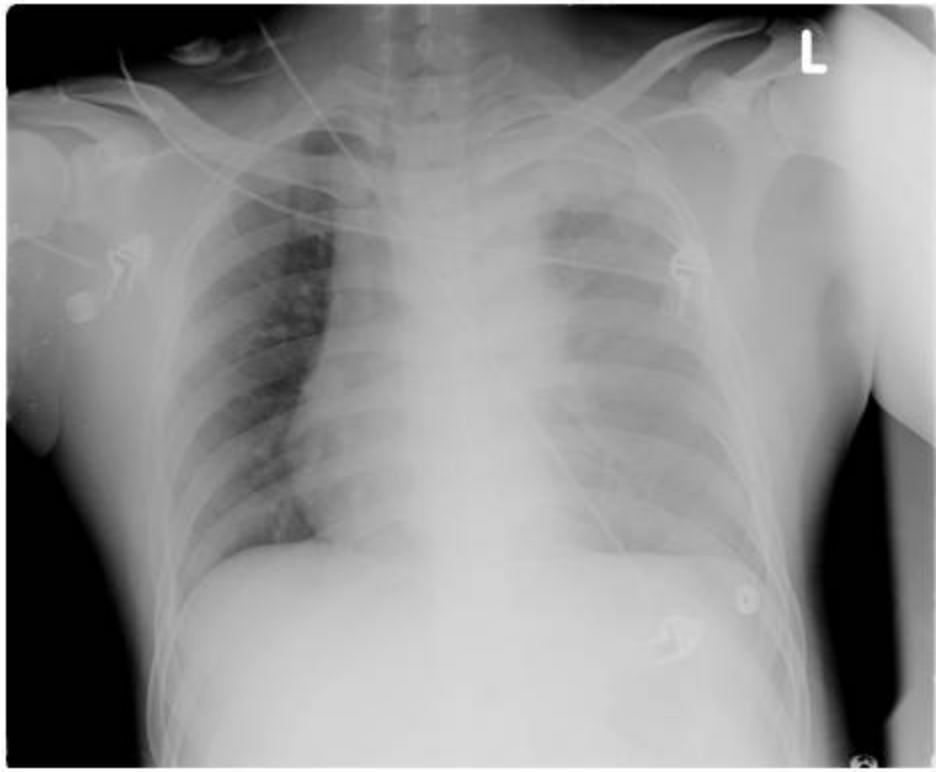
Most: lig. arteriosum

A clear aortic knob outline
- 90% negative predictive value
- may delay develop 6 – 36 hrs
- experienced reader



CXR for aortic transection
BAD MEAT

- Not reliable



- **B**ronchus depression
- **A**ortic silhouette shaggy
- **D**eath in 80-90%
- **M**ediastinal widening
- **E**ffusion without rib fx
- **A**pical cap (extrapleural hematoma along brachiocephalic vein)
- nasogastric **T**ube displacement

Limitations of CXR to Dx Traumatic aortic injury (TAI)

- Detects mediastinal hemorrhage only
- high false positive rate (lipomatosis, atelectasis)
- May rarely look “normal”

Secondary Survey

- more detailed and complete examination, aimed at identifying all injuries and planning further investigation and treatment.
- Rib Fractures & flail chest
- Pulmonary contusion
- Simple pneumothorax
- Simple haemothorax
- Blunt aortic injury
- Blunt myocardial injury

Development of Pneumothorax

- Anteromedial pneumothorax
  (least dependent)
- → Subpulmonary
- → Apicalateral
- → Tension pneumothorax

Radiographic signs of anteromedial pneumothorax

Suprahilar

sharp outline of:

a). superior vena cava

b). azygos vein

c). left subclavian art.

d). anterior junction line

Infrahilar

sharp outline of:

a).heart border

b).deep anterior cardiophrenic sulcus

c).medial diaphram

d).pericardial fat pad

Potential signs of pneumothorax

- Pleural line with absent markings
- Double diaphragm sign
  - Visible anterior costophrenic recess interface
- Sharpened cardiac silhouette & apex
- Hyperlucent hemithorax
- Inferior edge of collapsed lung
- Deep sulcus sign
- Depressed diaphragm
- Apical pericardial fat
  - Discrete lobulated densities (1-1 .5cm) adjacent to cardiac apex

Subpulmonic Pneumothorax

- hyperlucent upper quadrant of the abdomen
- deep lateral costophrenic sulcus
- outline of the anterior costophrenic sulcus and inferior lung surface.

Pneumothorax in Supine Patients

- Anteromedial - unusually sharp outline of:
  - Mediastinal vascular structures
  - Heart border
  - Cardiophrenic sulcus
- Posteromedial
  - Lucent band outlining mediastinal surface of a collapsed lower lobe
  - Increased visibility of paraspinous line & descending aorta
  - Increased visibility of posterior costophrenic sulcus
- Subpulmonic
  - Hyperlucent upper abdominal quadrant
  - Deep costophrenic sulcus (“deep sulcus” sign)
  - Sharp hemidiaphragm despite opacification in lower lobe of lung (if consolidated)
  - Visualisation of inferior surface of consolidated lung

Thoracostomy (Chest) Tube

- Distal tip not abut a mediastinal structure
- Two orthogonal projections may be needed to verify appropriate placement, also permit detection of tube placement in an interlobar fissure
- **Complication: persistent pleural effusion or pneumothorax**
- **CT scan is cost-effective for mal-function of chest tube**

- @ Detection of small pneumothoraces in supine critical patient treated with positive pressure ventilation will prevent their progression to lethal tension pneumothoraces.

Pulmonary Contusion

- Mask underlying injury
- Independent injury
- Resolve to normal
- Basilar contusions/lower rib fx:
  - Marker of intra-abdominal injury**

Beyond the Initial Assessment

- Diaphragm rupture
- Pulmonary lacerations
- Airway lacerations
- Chest wall injuries

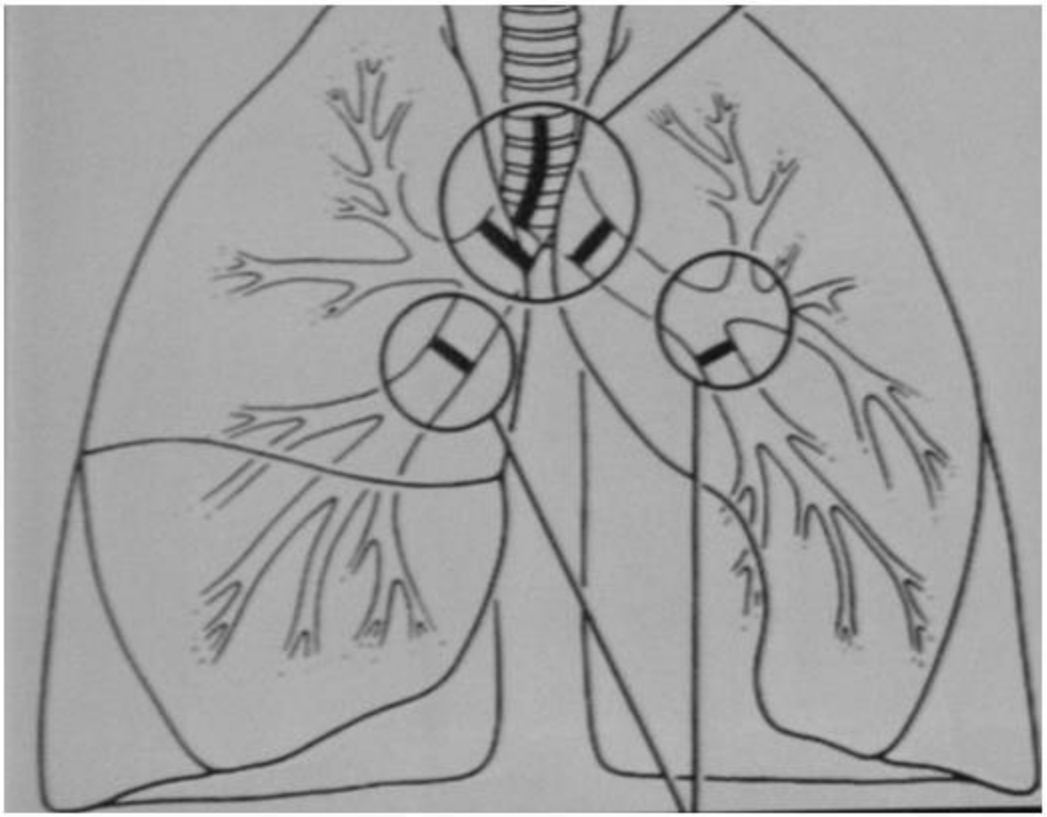
Delay diaphragmatic rupture?

- Intubation and positive pressure ventilation may Prevent herniation of abdominal organs until weaning is achieved

- Diaphragmatic injuries cannot be excluded if patients are intubated

Karmy-Janes et al. Am Surg 2002;68(2):167

Bronchial Rupture



- 85% within 2.5 cm of carina
  - Equal involvement, R=L

Non-traumatic PNEUMOMEDIASTINUM

Age:neonates (0.05-1%), 2nd-3rd decade

Causes:

(a)rupture of marginally situated alveoli from sudden rise in intraalveolar pressure (acute asthma, aspiration pneumonia, hyaline membrane disease, measles, giant cell pneumonia, coughing, vomiting, strenuous exercise, parturition, diabetic acidosis)

(b)tumor erosion of trachea / esophagus

(c)pneumoperitoneum / retropneumoperitoneum

= extension from peritoneal / retroperitoneal / deep fascial planes of the neck

Cx:air block = buildup of pressure impeding blood flow in low-pressure veins; particularly common in neonatal period

Pneumomediastinum

- Linear, vertically oriented streaks of air collect in the superior mediastinum, and dissect cephalad through the thoracic inlet.
- Subcutanoues emphysema in the soft tissue of the neck
- "V-sign of Naclerio" = air between lower thoracic aorta + diaphragm
- "Continuous diaphragm" sign: when air extend into the base of the heart
- Pneumoretroperitoneum

CXR Signs of Pneumomediastinum

- Thymic sail sign (infants/young children)
- Tubular artery sign (AP film)
- “Ring around the artery” sign (lateral film)
- Double bronchial wall sign
- Continuous diaphragm sign
- Extrapleural air
- Naclerio’s V sign

- Linear density parallel to heart border
- Dissection of air into neck
- Dissection of air into chest wall

Pneumomediastinum vs pneumothorax

TABLE 2: Pneumomediastinum Versus Pneumothorax

Feature	Characteristic	
	Pneumomediastinum	Pneumothorax
Configuration of gas	Multiple thin, lucent streaks; can be confused with pneumothorax when streaks extend along diaphragm, over lung apex, or behind sternum	Apical lucency (upright); medial basal lucency (supine); deep-sulcus sign (supine)
Distribution	Outlines mediastinal structures (pulmonary artery, aorta, esophagus, and airway)	Never outlines mediastinal structures; anteromedial (supine); apical (upright)
Change in distribution with change in patient position?	No	Yes

Pneumomediastinum vs pneumocardium

TABLE 3: Pneumomediastinum Versus Pneumopericardium

Feature	Characteristic	
	Pneumomediastinum	Pneumopericardium
Configuration of gas	Multiple thin, lucent streaks	Broad band; halo sign (gas surrounding heart)
Distribution[a]	Outlines mediastinal structures, including aortic arch, trachea, and bronchi; commonly extends into neck	Because limited to pericardium, outlines ascending aorta and main pulmonary artery but does not extend to aortic arch, along trachea or bronchi, or into neck
Change in distribution with change in patient position?	No	Yes
Associated findings	See text	Visible thickening of pericardium; hydropneumopericardium

[a]Both pneumomediastinum and pnemopericardium can give rise to continuous diaphragm sign.

Trauma

Acute chest pain

Dyspnea

Fever

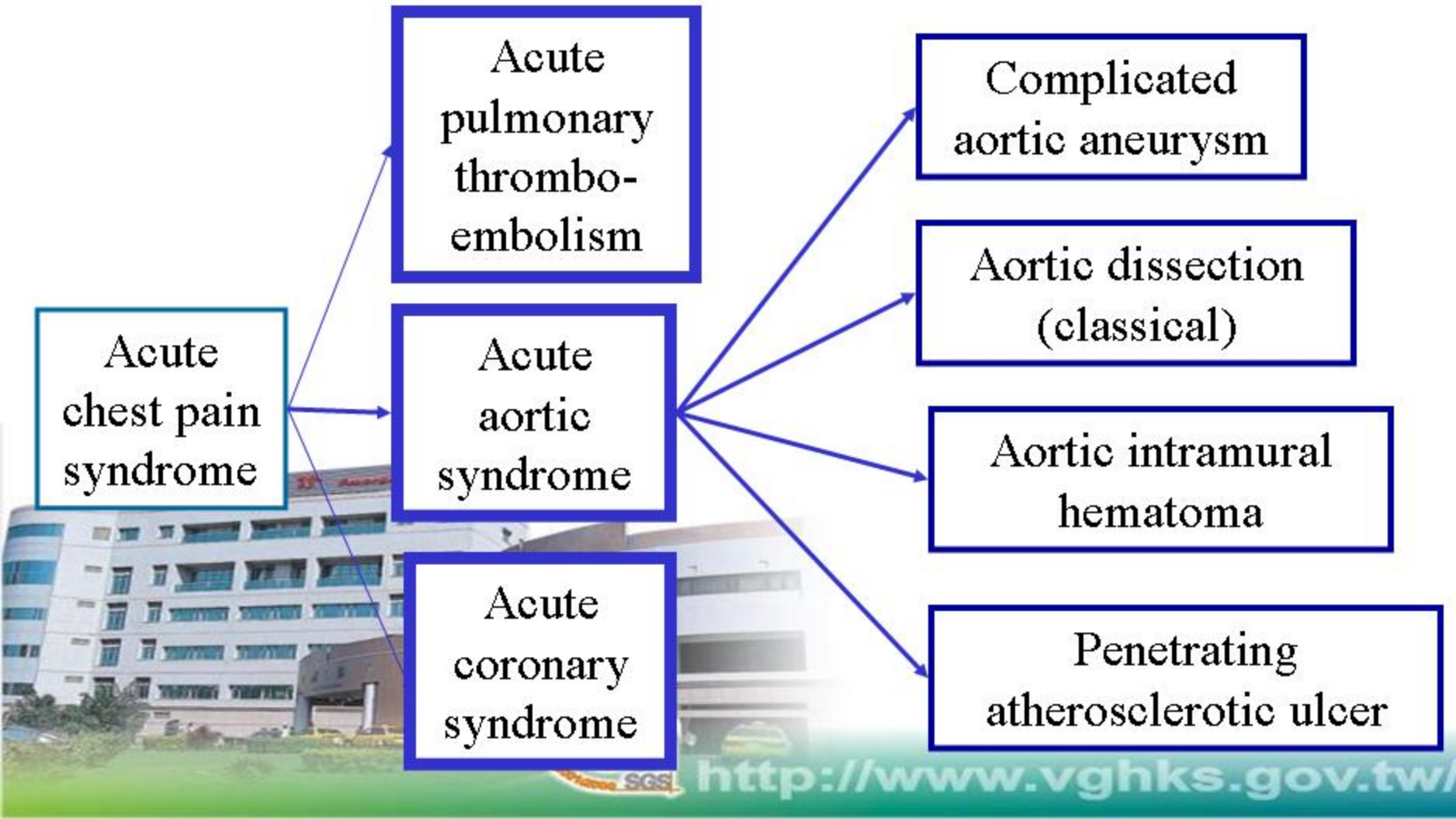
Iatrogenesis imperfecta

One-stop shop for acute chest pain syndrome

64-slice + ECG: optimal

16-slice, +ECG gated, 20 sec. doable

6-slice, +ECG, 40 sec. Not practical



CXR of Aortic Dissection

normal CXR in 25%

"calcification sign" = inward displacement of atherosclerotic plaque by >4-10 mm from outer aortic contour (7%), can only be applied to contour of descending aorta secondary to projection, may be misleading in presence of periaortic soft-tissue mass / hematoma

disparity in size between ascending + descending aorta

irregular wavy contour / indistinct outline of aorta

widening of superior mediastinum to >8 cm due to hemorrhage / large false channel (40-80%)

cardiac enlargement (LV hypertrophy / hemopericardium)

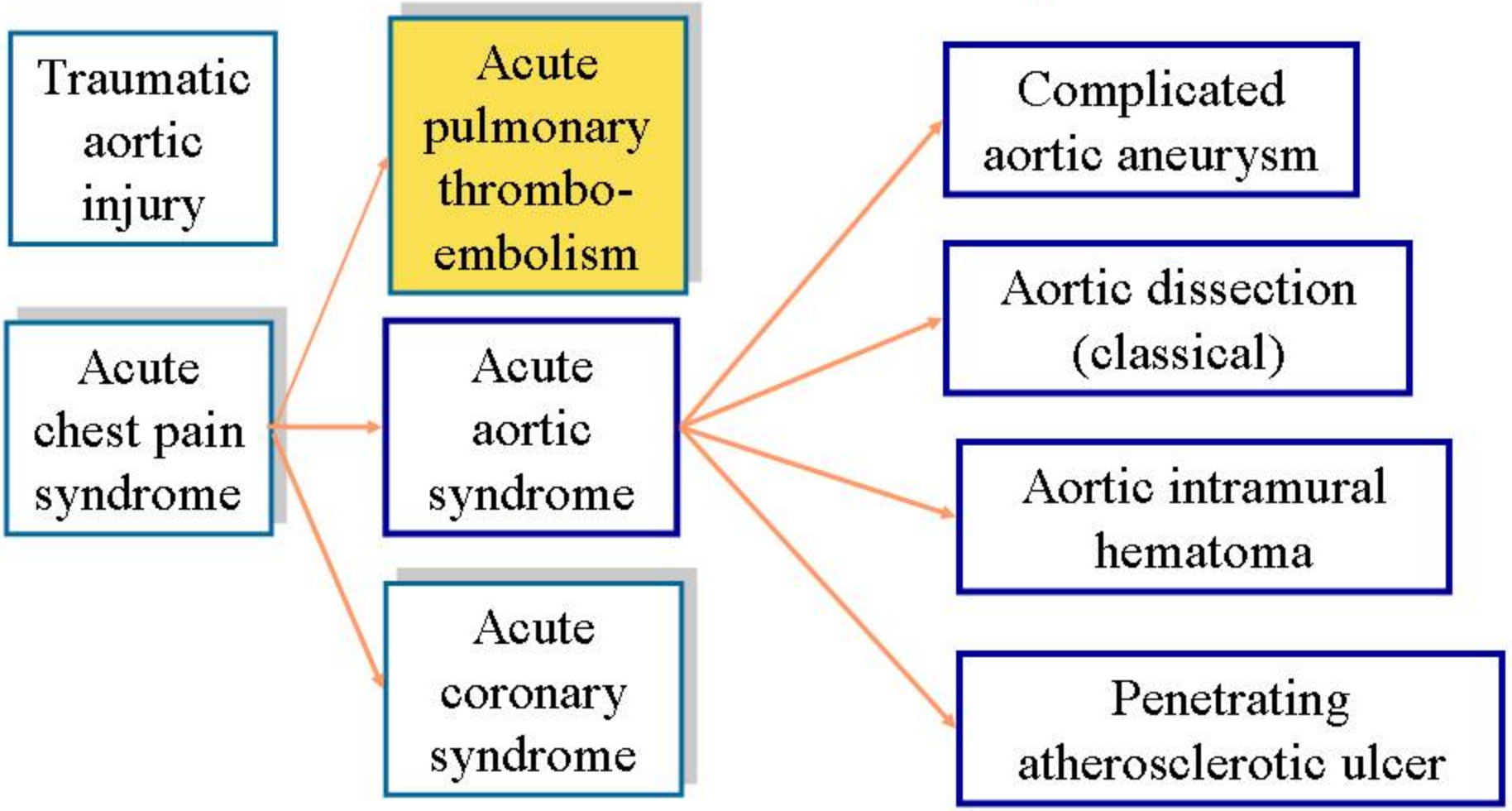
left pleural effusion (27%)

atelectasis of lower lobe

rightward displacement of trachea / endotracheal tube

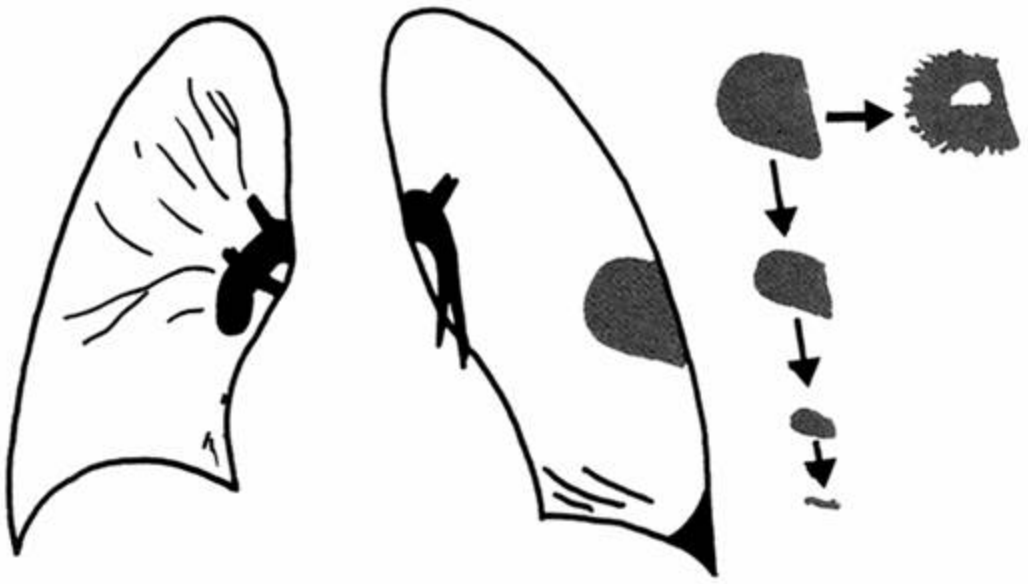
Acute chest pain syndrome

for details, please refer to my powercam "MDCT of acute chest pain"



Pulmonary thromboembolsim CXR findings

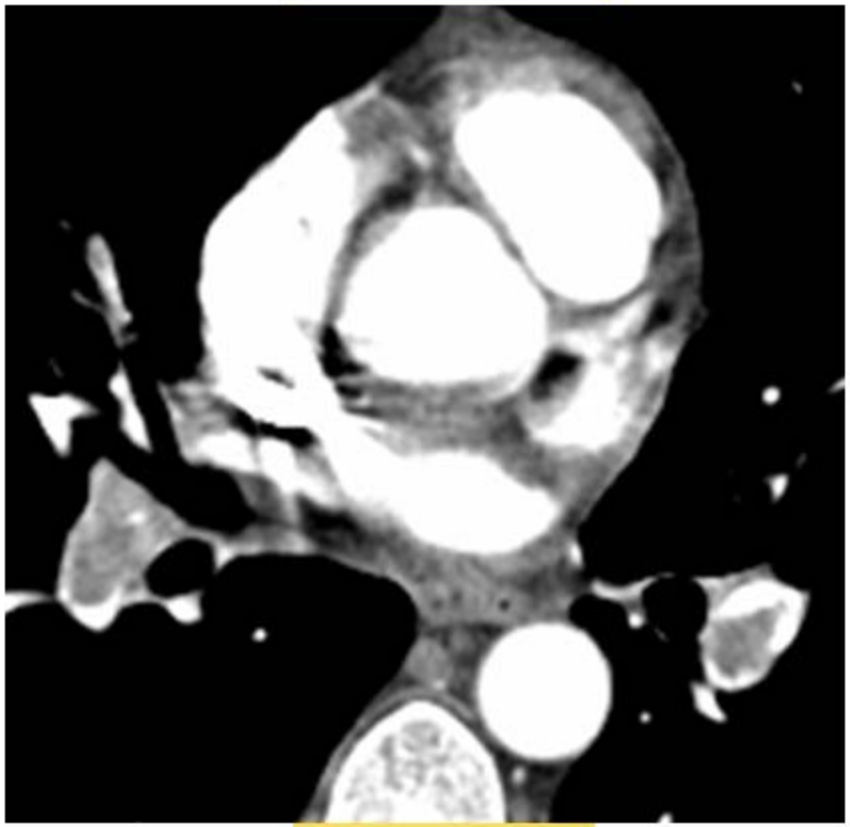
- May be normal (20-30%); Nonspecific findings
- Regional oligemia (Westermark sign)
- Peripheral, pleural-based, wedge-shaped areas of increased lung density (Hampton Hump)
- Prominence of central pulmonary arteries (Fleischner sign)(Knuckle sign)
- Gradual resolution of the hump (Melting sign)



- Knuckle sign
- Westermark sign
- Elevation of diaphragm
- "Melting iceberg" sign
- Infarct shadow

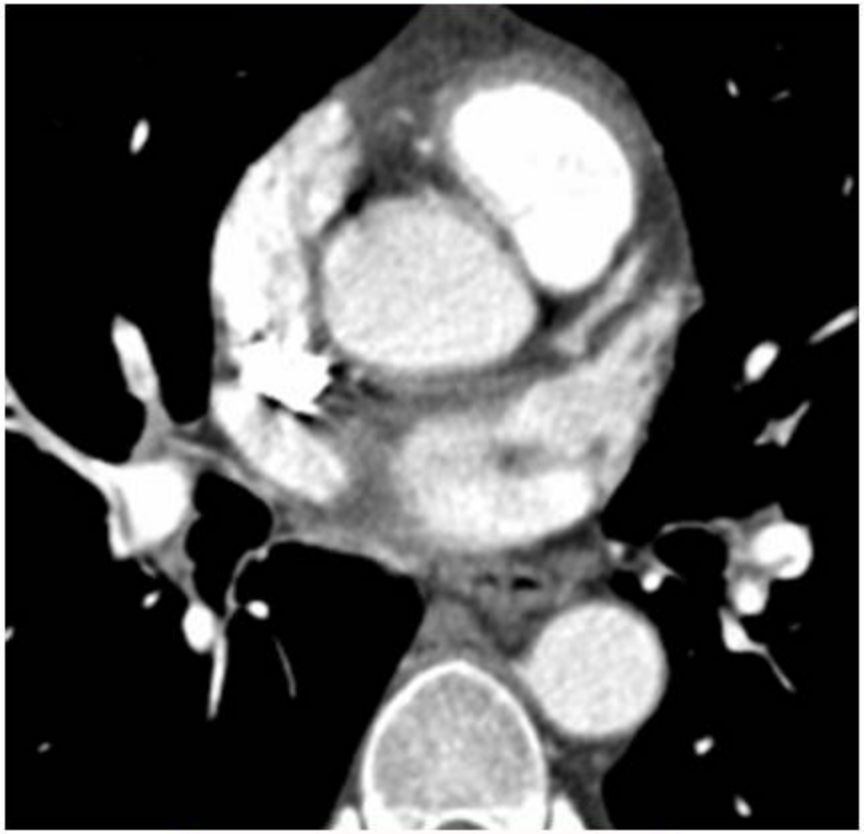
Pulmonary thromboembolism
CT findings

Acute phase



Target sign

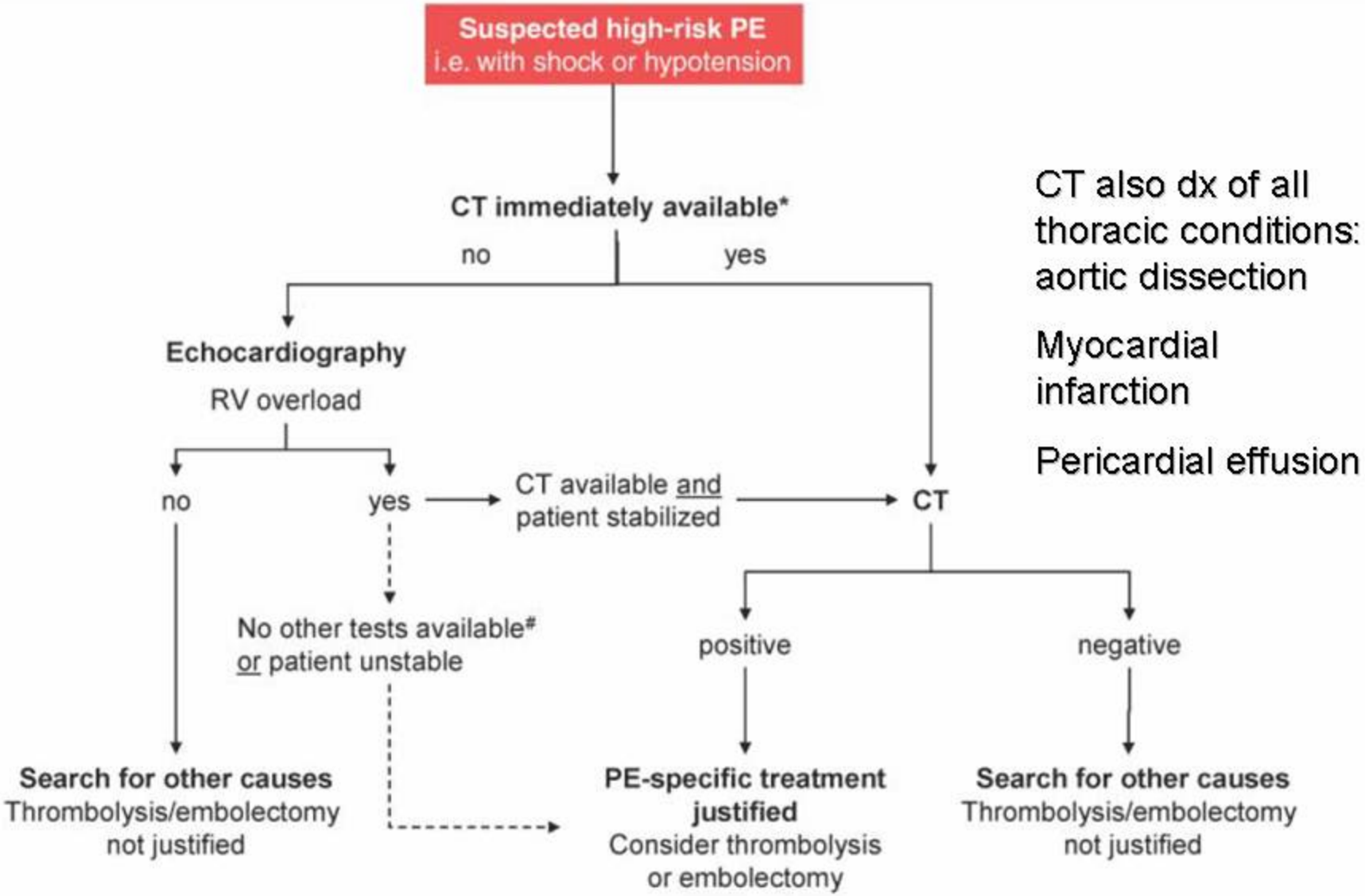
Chronic phase



Recannulization
webs and strictures

ESC 2008 guideline of acute PE

European Heart J 2008; 29: 2276-2315

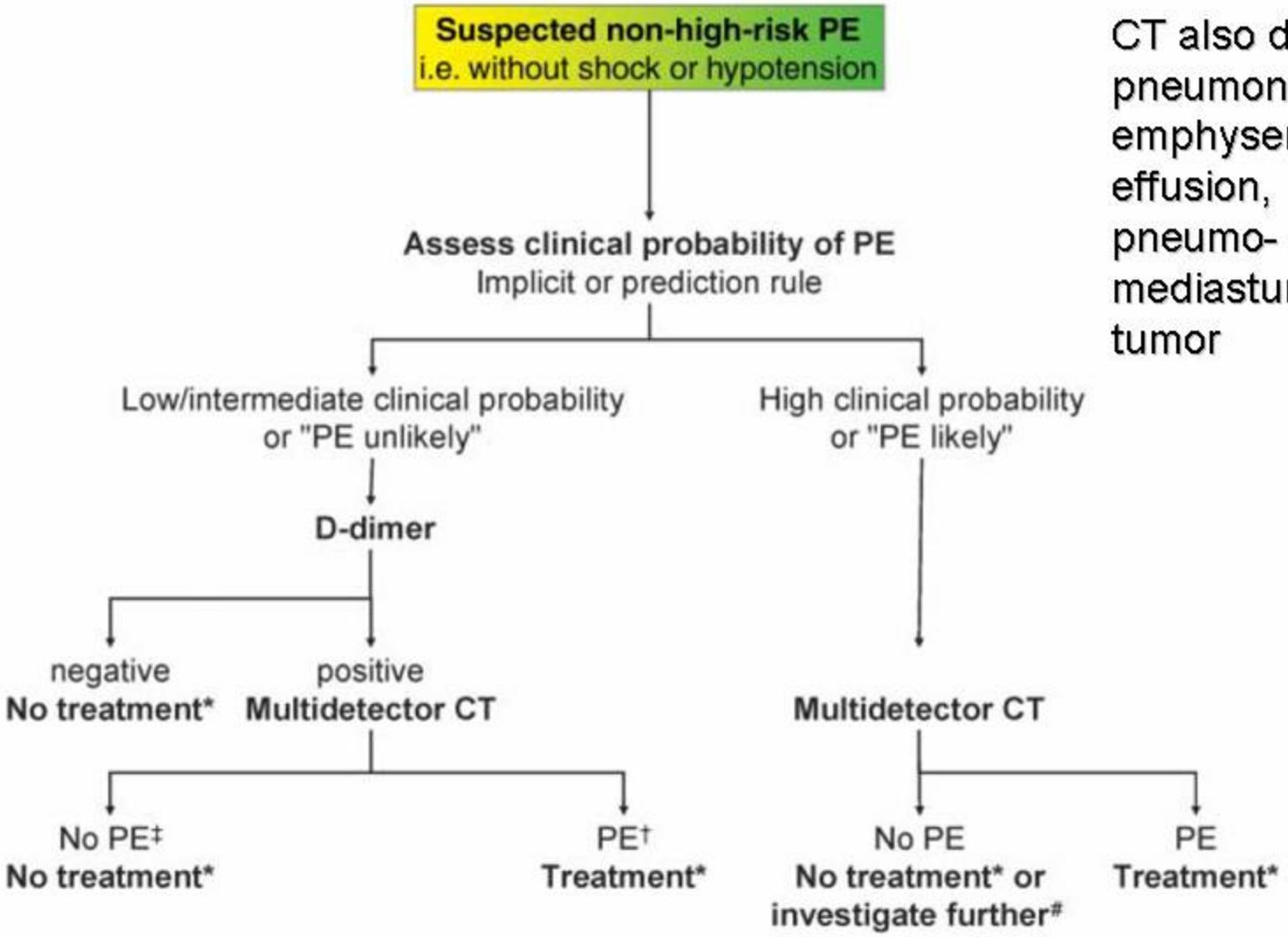


CT also dx of all thoracic conditions:
aortic dissection

Myocardial infarction

Pericardial effusion

MDCT: most accurate-efficient imaging test for PE



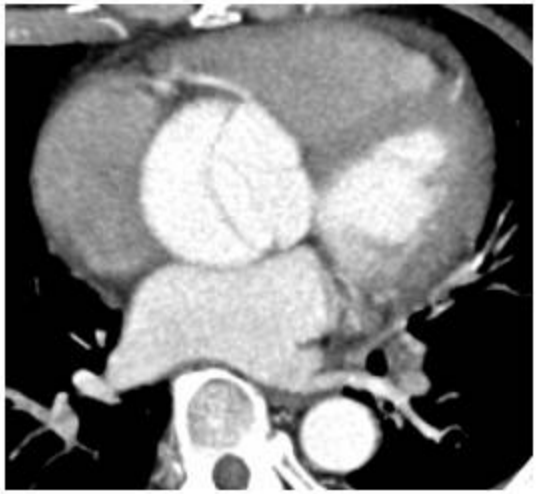
CT also dx of :
pneumonia,
emphysema,
effusion,
pneumo-
mediastum,
tumor

64-slice CT for acute chest pain
one-stop shop for triple rule-out

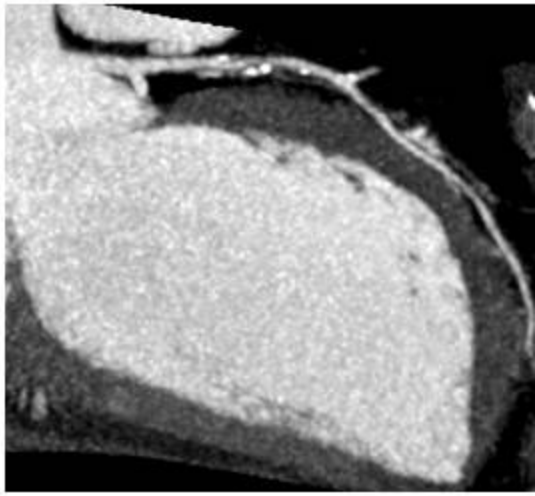
for details, refer to my powercam
"MDCT of acute chest pain"

Acute pulmonary emboli

Acute aortic syndrome



Acute coronary syndrome



Trauma

Acute chest pain

Dyspnea

Fever

Iatrogenesis imperfecta

Cardiac tamponade

rapidly appearing cardiomegaly
“water bottle configuration" = symmetrically enlarged cardiac silhouette
Normal /decrease of pulmonary vascularity

Collagen vascular disease
Uremia
Metastasis
Trauma
Acute myocardial infarction
Purulent infection
Post MI syndrome
Idiopathic
Tuberculosis
Rheumatoid arthritis
Virus

FAT EMBOLISM

=obstruction of pulmonary vessels by fat globules followed by chemical pneumonitis from unsaturated plasma fatty acids producing hemorrhage / edema

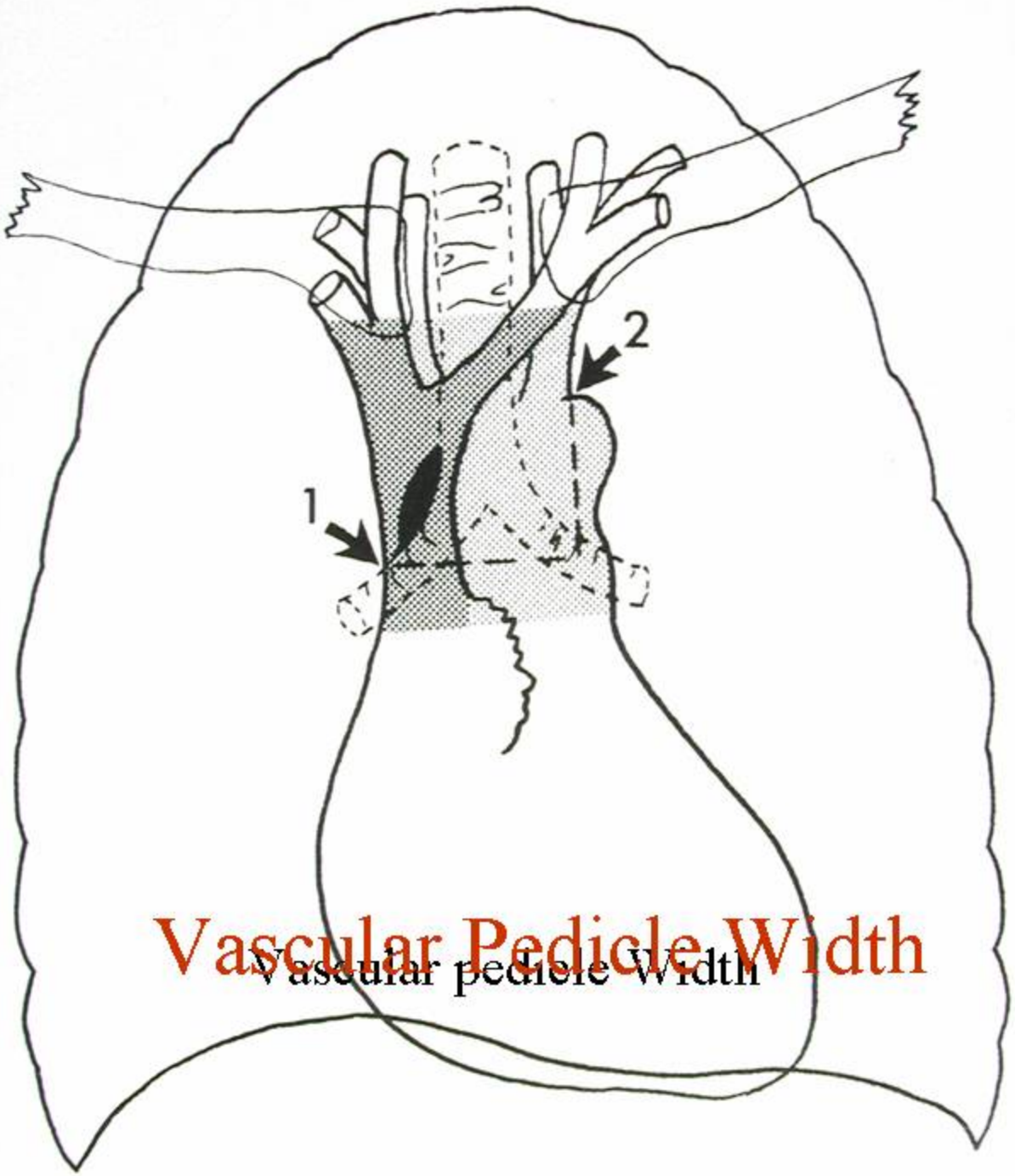
Incidence:in necropsy series in 67-97% of patients with major skeletal trauma, however, symptomatic fat embolism syndrome in <10% (M > F)

Onset:24-72 hours after trauma

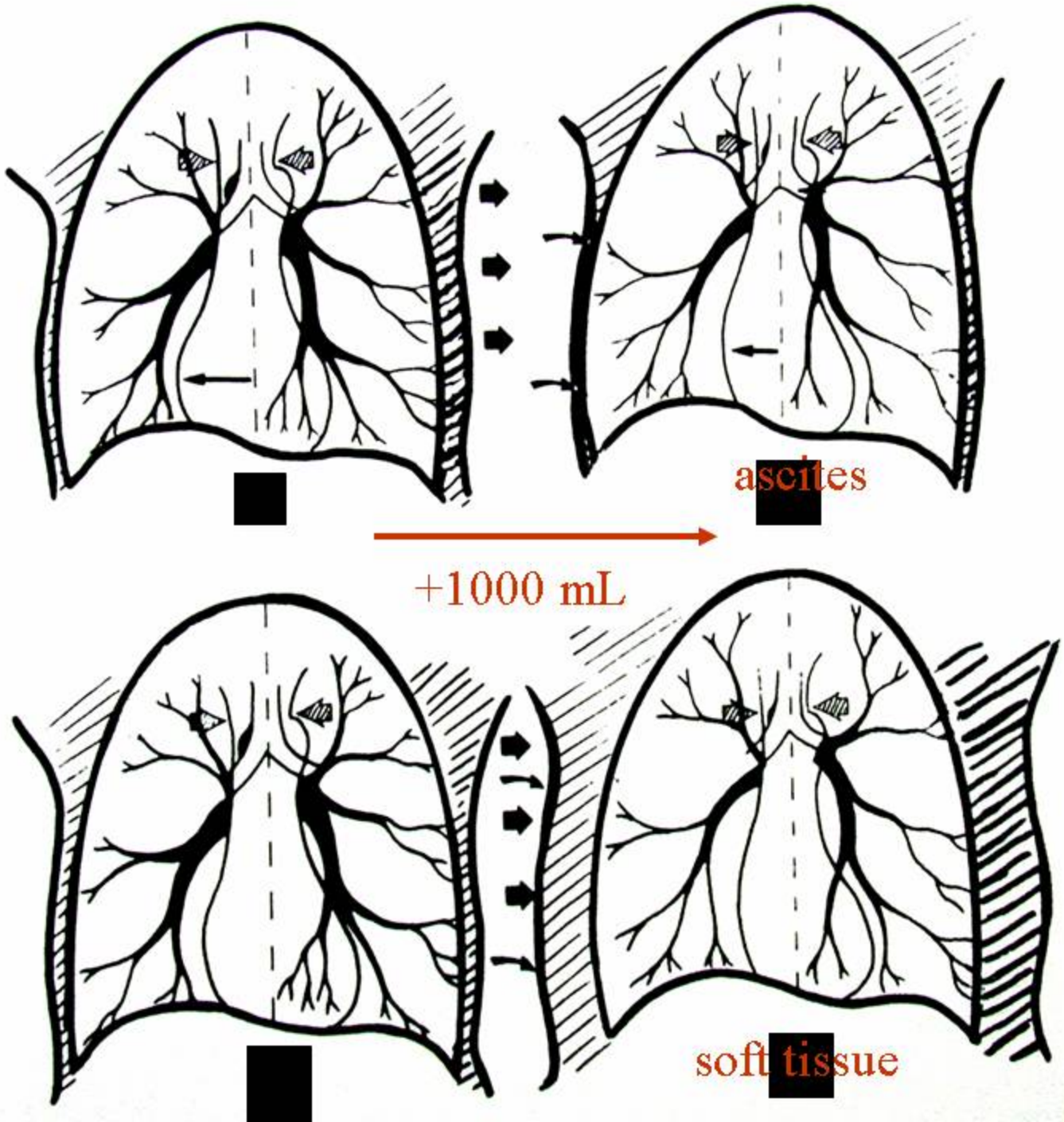
- dyspnea (progressive pulmonary insufficiency)
- fever
- systemic hypoxemia
- mentation changes: headaches, confusion
- petechiae (50%) from coagulopathy (release of tissue thromboplastin)
- initial chest film usually negative (normal up to 72 hours)
- platelike atelectasis
- bilateral diffuse alveolar infiltrates
- consolidation (may progress to ARDS)

Intravascular Fluid Status

- **Width of vascular pedicle** correlates well with total intravascular blood volume
- Pulmonary blood volume increases very slightly
- **Serial evaluation** of the vascular pedicle
- Recognition of fluid overload depends on an integration of clinical and radiographic findings: peripheral edema, fluid I/O, urinalysis, daily weight
- **Pulmonary artery occlusion pressure** correlate with development of interstitial and alveolar edema. Many technique and interpretation pitfalls. It should not be used as a standard against clinical and radiological findings



Vascular Pedicle Width


ascites
+1000 mL
soft tissue

Trauma

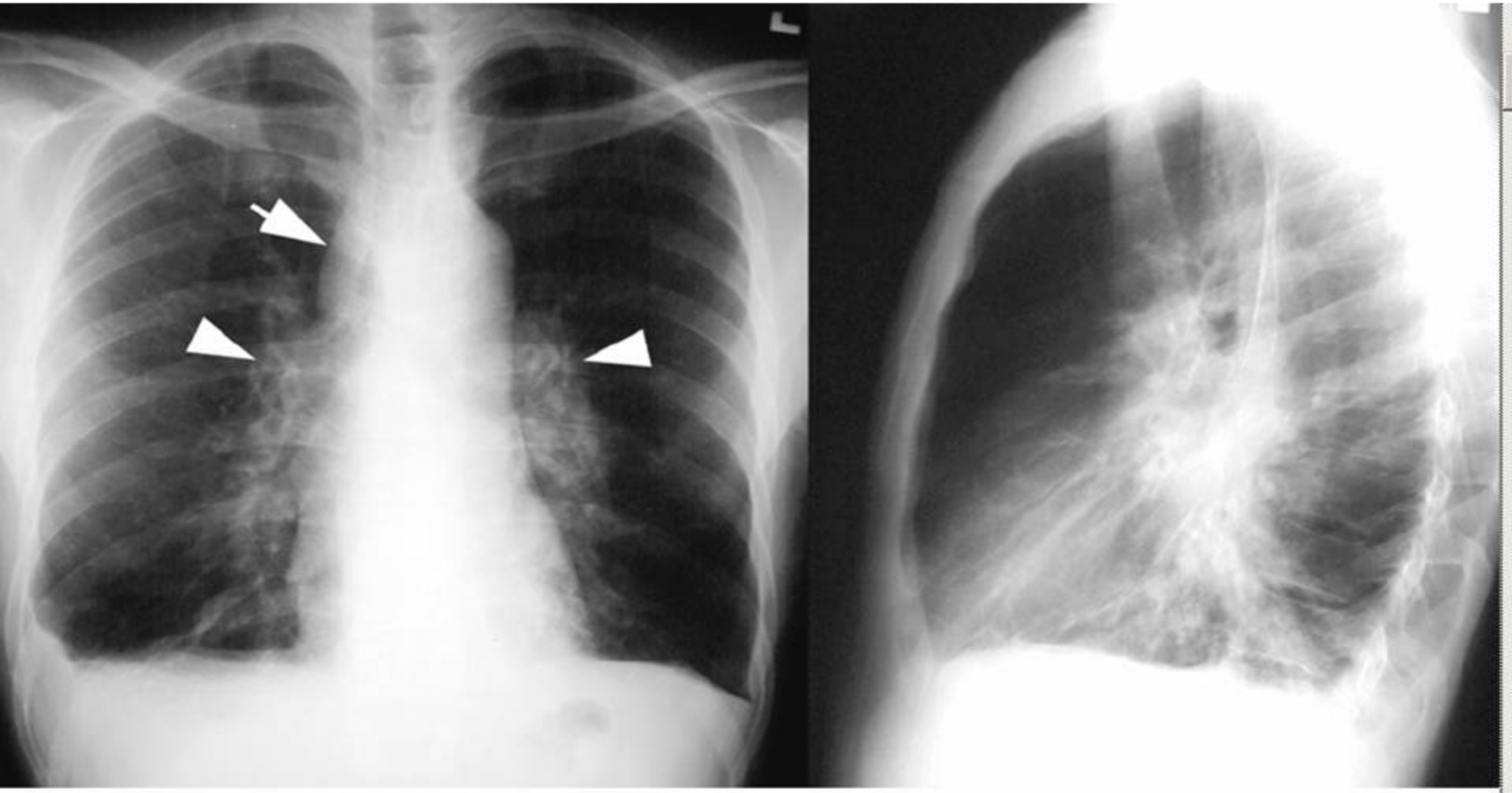
Acute chest pain

Dyspnea

Fever

Iatrogenesis imperfecta

Initial CXR at ER



Inhalational Anthrax

JAMA 2002: 286:2549- 53
Radiology 2001: 222: 305-12

- Massive hemorrhagic mediastinitis
- Widening mediastinum with flulike symptoms + exposure
- Hilar adenopathy, pleural effusions and peripheral airspace disease
- CXR leads many hours or days before blood culture proved
- Inhalational Anthrax after bioterrorism exposure

Emergent Acute Lung Diseases

- Acute eosinophilic pneumonia
- Anthrax
- SARS
- Influenza, Bird-flu
- Hantavirus
- Non tuberculous mycobacteria
- Aspergillus

Trauma

Acute chest pain

Dyspnea

Fever

Iatrogenesis imperfecta

Endotracheal Tube

- End of tube to the carina
- Neck neutral 5 – 7 cm
- Neck flexed 3 – 5 cm
- Neck extended 7 – 9 cm

- Tracheal rupture by the cuff: pnemomediastinum

Routine CXR following endotracheal tube

- In a prospective study of 219 cases, 14% requires adjustments of position. 5% (10/219) was placed in the main bronchus; 6/10 of patients were unsuspected by physical, acoustic examination and the depth-mark of the ETT. (3%)

  – Brunel et al. Chest 1989; 96: 1043-45

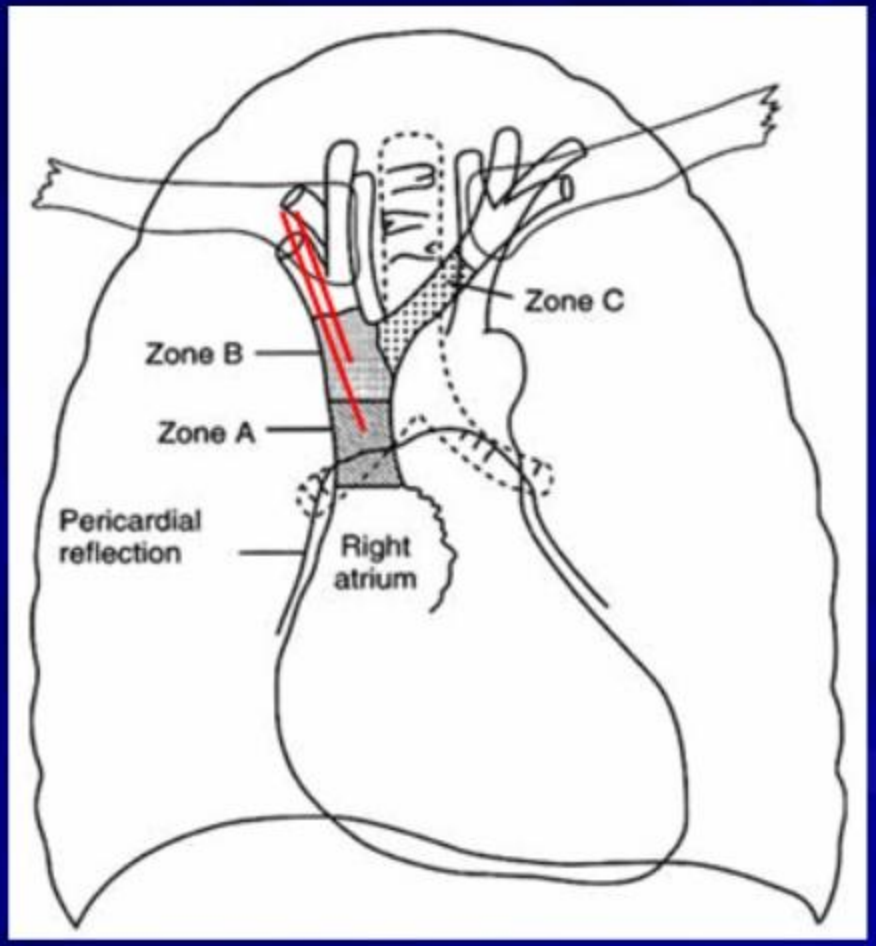
Central Venous Catheter

- Route: from a subclavian vein or jugular vein directed vertically into SVC,
- Intramural perforation: impingemnet against the lateral wall of SVC, or with abrupt angulation at the tip
- Tip location: should not in the right atrium
- Complication: hematoma, pnemo-mediastinum, dislocation of catheter

Central line positioning - issues

- Right upper heart border is left atrium, not the right, in 38% of patients
- Radiographic SVC/RA junction:
  - hard to see in 10%
  - inaccurate: can be up to 2.8 cm higher than echocardiographic junction
  - not all lines within heart shadow on xray are in the RA
- CVC tip should lie
  - in SVC
  - above pericardial reflection (but no radiographic marker of this structure)
  - BUT is acceptable for dialysis line tip to lie at SVC/RA junction or in RA

- Line should lie parallel to vessel wall
- Line tip < 2.9 cm beyond take-off of right main bronchus is *always* in SVC
- Right tracheobronchial angle is *always* below junction of brachiocephalic veins
- Carina is mean of 1.3 cm below mid-point of the SVC and up to 0.7 cm below pericardial reflection – is suitable location for line tip

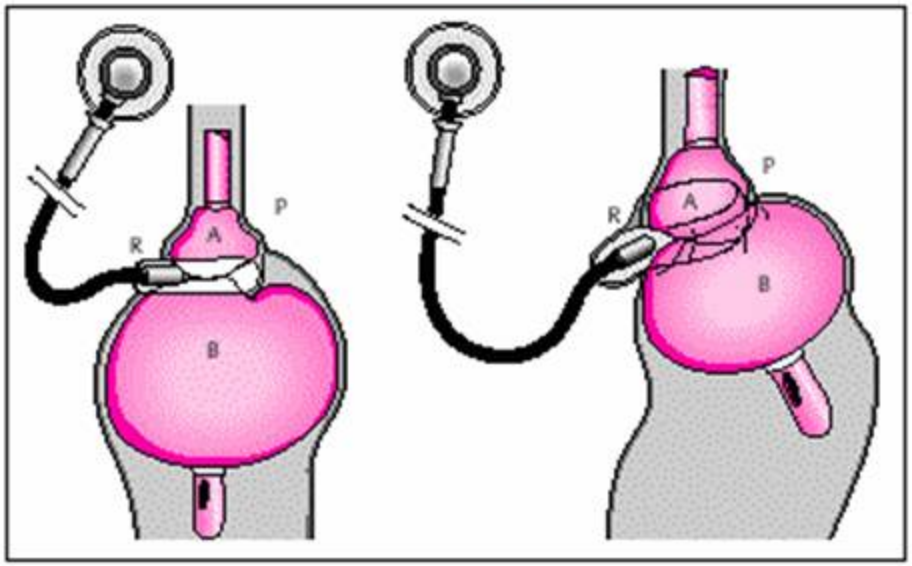


British Journal of Anaesthesia 2006 96(3):335-340

Pulmonary Artery (Swan-Ganz) Catheter

- Tip in central left and right main pulmonary artery; proximal interlobar artery
- 25% malposition in heart or distal into segmental artery
- No loop in the right atrium / ventricle (may precipitate arrhythmias and undetected distal migration)
- Complication: pneumothorax, hemothorax, pulmonary infarction, arrhythmia pleural effusion, inflitrates.
- **BEWARE OF L-SVC**

Sengstaken-Blakemore Tube



- Tip and side holes
- In stomach or duodenum. Beyond the GE junction
- Complication: tracheobronchial placement, pneumothorax, infiltrate

The NEW ENGLAND JOURNAL of MEDICINE

IMAGES IN CLINICAL MEDICINE

Malposition of a Sengstaken–Blakemore Tube

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An 86-year-old woman had a history of cirrhosis associated with chronic hepatitis B infection lasting more than 16 years; she had had five episodes of esophageal variceal bleeding that had required placement of a Sengstaken–Blakemore tube for tamponade and had undergone subsequent sclerotherapy. The patient presented to the emergency department with a new episode of hematemesis, and a Sengstaken–Blakemore tube was placed. Subsequently, the patient had pain in the left chest area, and chest radiography showed a malpositioned gastric balloon (Panel A). Computed tomography of the chest showed that the tube had penetrated the esophageal wall (arrow, Panel B), with the gastric balloon visible in the left pleural cavity. Emergency surgical repair was suggested but declined by the patient and her family. Left empyema developed, and the patient died of septic shock two weeks later. Complications of the implantation of a Sengstaken–Blakemore tube are commonly associated with the inflation of the gastric balloon outside the stomach.

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