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

高雄榮總放射線部
胸腔循環影像醫學科 吳銘庭 醫師

http://www.vghks.gov.tw/
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 bluetooth to PACS
- Bluetoth 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

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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 deceleration 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
- Bronchus depression
- Aortic silhouette shaggy
- Death in 80-90%
- Mediastinal widening
- Effusion without rib fx
- Apical cap (extrapleural hematoma along brachiocephalic vein)
- nasogastric Tube displacement
Limitations of CXR to Dx Traumatic aortic injury (TAI)

- Detects mediastinal hemorrhage only
- High false positive rate (lipomatosisis, 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 diaphragm
  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 malfunction 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.

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.
- Subcutaneous emphysema in the soft tissue of the neck.
- "V-sign of Naclerio" = air between lower thoracic aorta + diaphragm
- "Continuous diaphragm" sign: when air extends 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
### TABLE 2: Pneumomediastinum Versus Pneumothorax

<table>
<thead>
<tr>
<th>Feature</th>
<th>Characteristic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Configuration of gas</strong></td>
<td></td>
</tr>
<tr>
<td>Pneumomediastinum</td>
<td>Multiple thin, lucent streaks; can be confused with pneumothorax when streaks extend along diaphragm, over lung apex, or behind sternum</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>Apical lucency (upright); medial basal lucency (supine); deep-sulcus sign (supine)</td>
</tr>
<tr>
<td><strong>Distribution</strong></td>
<td></td>
</tr>
<tr>
<td>Pneumomediastinum</td>
<td>Outlines mediastinal structures (pulmonary artery, aorta, esophagus, and airway)</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>Never outlines mediastinal structures; anteromedial (supine); apical (upright)</td>
</tr>
<tr>
<td><strong>Change in distribution with change in patient position?</strong></td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
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<td>---------------------------------------</td>
<td>-------------------------------------------------------</td>
</tr>
<tr>
<td>Configuration of gas</td>
<td>Multiple thin, lucent streaks</td>
</tr>
<tr>
<td>Distribution(^a)</td>
<td>Outlines mediastinal structures, including aortic arch, trachea, and bronchi; commonly extends into neck</td>
</tr>
<tr>
<td>Change in distribution with change in patient position?</td>
<td>No</td>
</tr>
<tr>
<td>Associated findings</td>
<td>See text</td>
</tr>
</tbody>
</table>

\(^a\)Both pneumomediastinum and pneumopericardium 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

- Acute pulmonary thromboembolism
- Complicated aortic aneurysm
- Aortic dissection (classical)
- Aortic intramural hematoma
- Penetrating atherosclerotic ulcer

Acute chest pain syndrome

Acute aortic syndrome

Acute coronary syndrome
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”

- Traumatic aortic injury
- Acute pulmonary thromboembolism
- Acute chest pain syndrome
- Acute aortic syndrome
  - Complicated aortic aneurysm
  - Aortic dissection (classical)
  - Aortic intramural hematoma
  - Penetrating atherosclerotic ulcer
- Acute coronary syndrome
Pulmonary thromboembolism
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)
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

Suspected high-risk PE
i.e. with shock or hypotension

CT immediately available*
no

Echocardiography
RV overload

no

Search for other causes
Thrombolysis/embolectomy not justified

yes

CT available and patient stabilized

no

No other tests available* or patient unstable

Search for other causes
Thrombolysis/embolectomy not justified

positive

PE-specific treatment justified
Consider thrombolysis or embolectomy

negative

Search for other causes
Thrombolysis/embolectomy not justified

CT also dx of all thoracic conditions:
aortic dissection
Myocardial infarction
Pericardial effusion
MDCT: most accurate-efficient imaging test for PE

Suspected non-high-risk PE
i.e. without shock or hypotension

Assess clinical probability of PE
Implicit or prediction rule

Low/intermediate clinical probability
or "PE unlikely"

- D-dimer
  - negative: No treatment*
  - positive: Multidetector CT
    - No PE: No treatment*
    - PE+: Treatment*

High clinical probability
or "PE likely"

- Multidetector CT
  - No PE: No treatment* or investigate further#
  - PE: Treatment*

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
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: pneumomediastinum
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%)

Central Venous Catheter

- Route: from a subclavian vein or jugular vein directed vertically into SVC,
- Intramural perforation: impingement against the lateral wall of SVC, or with abrupt angulation at the tip
- Tip location: should not be in the right atrium
- Complication: hematoma, pneumo-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
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, infiltrates.
- **BEWARE OF L-SVC**
Sengstaken-Blakemore Tube

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