

Some Fundamentals

Arterial-Alveolar Gradient

$$\text{A-a Gradient} = \boxed{\text{Measured PaO}_2} - \boxed{\text{Calculated PaO}_2}$$

Quick A-a formula: $150 - (\text{PaCO}_2 \times 1.2 + \text{PaO}_2)$

- Normal: 10-15mm Hg (increases with age)

	<u>MECHANISM</u>	<u>EXAMPLE PATHOLOGY</u>
• Increased:	Shunt	ASD, AV Fistula
	VQ Mismatch	PE, COPD, Pneumonia
	↓ Diffusion	Interstitial Disease

Some Fundamentals

Cyanosis



Central cyanosis
(seen in the tongue)



The “blue bloater”

- Central cyanosis only clinically apparent with **>5g/dL** desaturated Hb
- Cannot be both anemic **and** cyanotic because cyanosis requires >5g/dL of desaturated Hb (e.g. having >5g/dl desaturated Hb with a total Hb of 8 is clinically impossible)
- Cyanosis is more likely if also polycythemic (e.g. the blue bloater) – (e.g. easy to have >5g/dl of desaturated Hb with a total Hb of 18)

Some Fundamentals

Pitfalls of the Pulse Oximeter

- **Anemia**
 - Pulse ox does not consider Hgb level
- **Supplemental O₂**
 - Can mask severe pulmonary process (i.e. when there is an \uparrow A-a gradient)
- **Carboxyhemoglobinemia (CO)**
 - Looks like 100% oxyhemoglobin (e.g. false sat of 100%)
- **Methemoglobinemia**
 - Looks like 85% oxyhemoglobin (e.g. false sat of 85%)



Asthma (1)

Epidemiology

- **Mortality greater in:**
 - African American and Latinos
 - Females
 - Adults
- **Factors associated with asthma prevalence**
 - Developed nations
 - Urban areas
- **Factors associated with mortality/morbidity:**
 - Poverty / lack of access
 - *Overuse* of OTC inhalers / episodic treatment
 - *Under use* of early steroids



Asthma (2)

Pathophysiology

- **Asthma is a chronic inflammatory disease**
- **Reduced airway diameter 2° to:**

Reversibility



Bronchial **constriction**

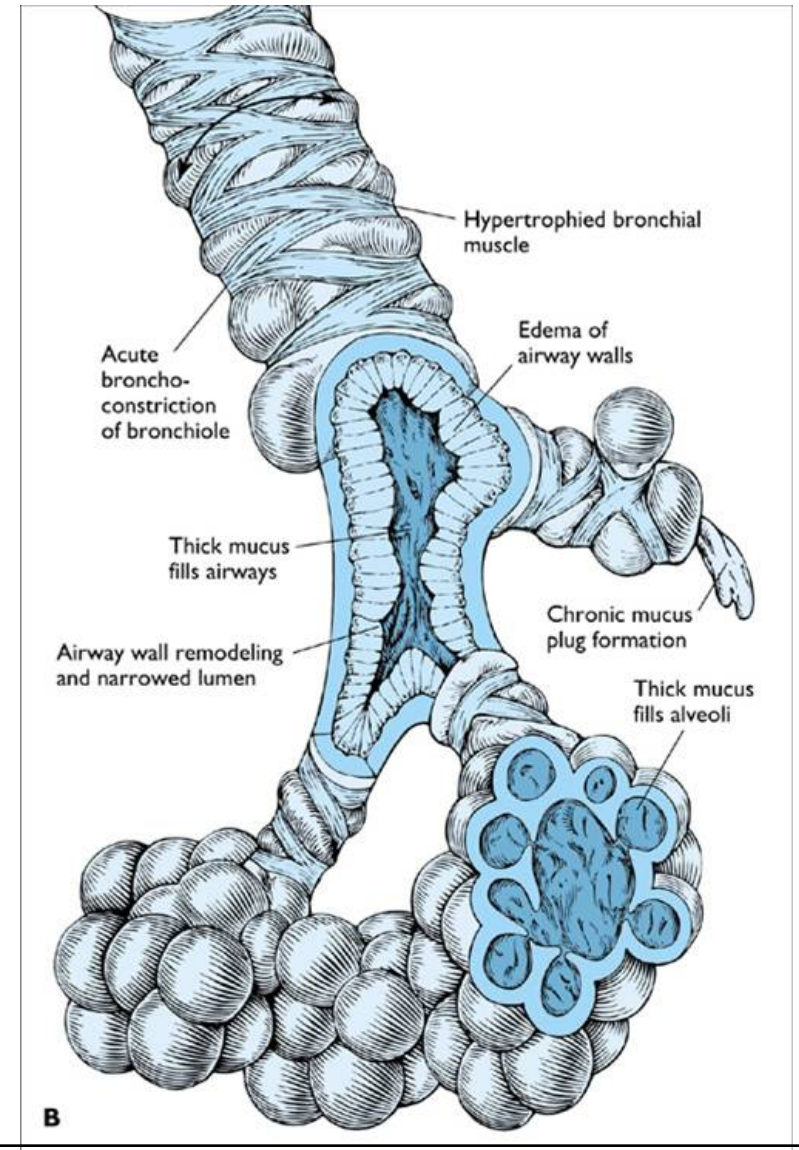
Bronchial **edema**

Mucous **plugging**

Increased **goblet cells**

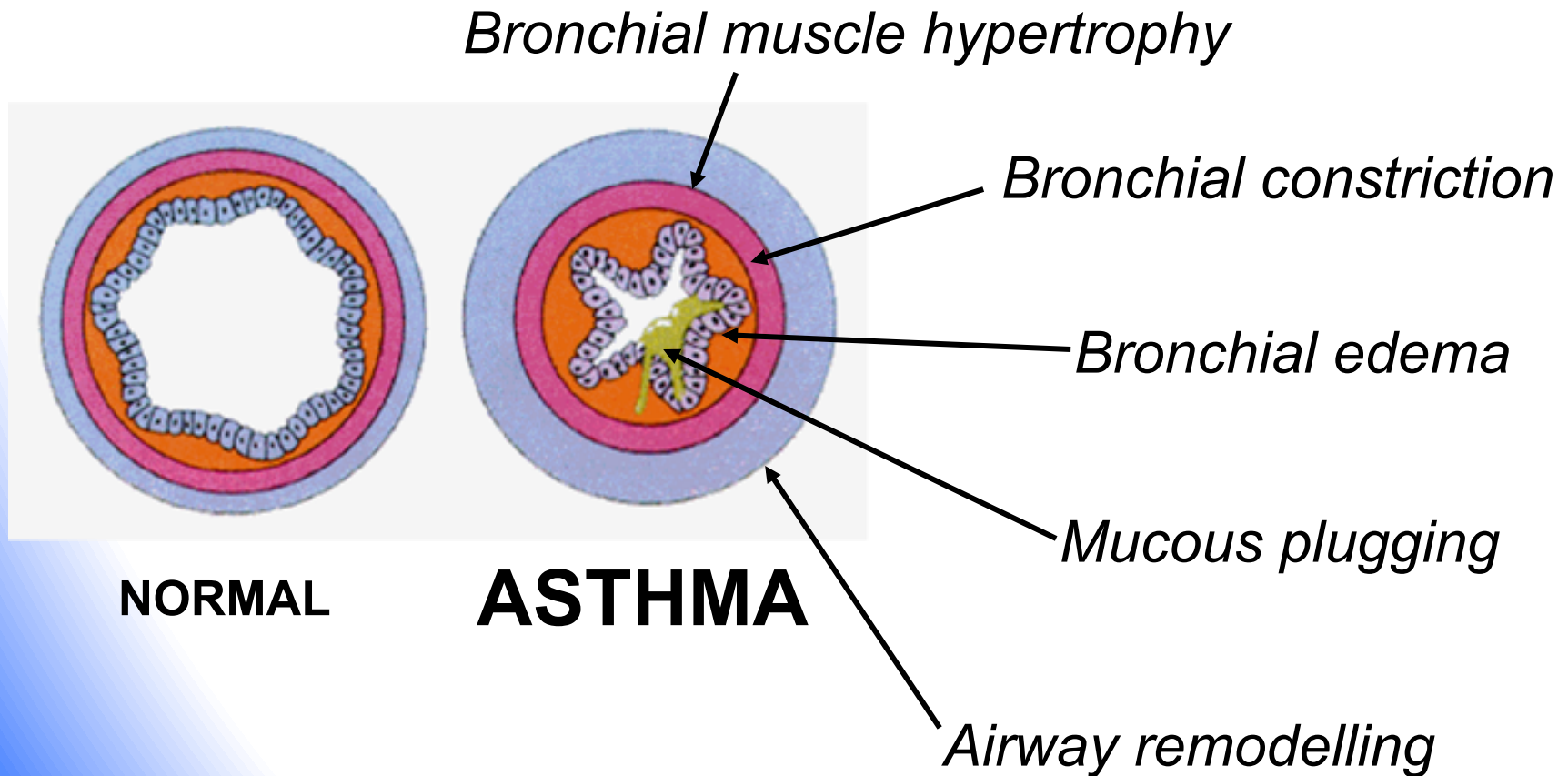
Bronchial **muscle hypertrophy**

Airway **remodelling**



Asthma (3)

Pathophysiology



Asthma (4)

Pathophysiology



A bronchial cast of inspissated mucus at autopsy 8

Asthma (5)

Precipitants

- **URI (#1)**
- Allergy
- Respiratory irritants (smoke, chemicals)
- Cold
- Exercise
- GERD
- Beta blockers (even eye drops)
- Methacholine
- ASA, NSAIDs (*triad with nasal polyps*)
- Menstruation
- Psychological

Clinical Features

- **Decreased expiratory flow**
- **Air trapping & barotrauma**
 - Pneumothorax
 - Pneumomediastinum
- **Decreased venous return**
 - Hypotension
 - Pulsus paradoxus
- **Hypercarbia → hypoxemia**
- **Muscle fatigue**
 - Respiratory failure

Asthma (6)

Diagnosis

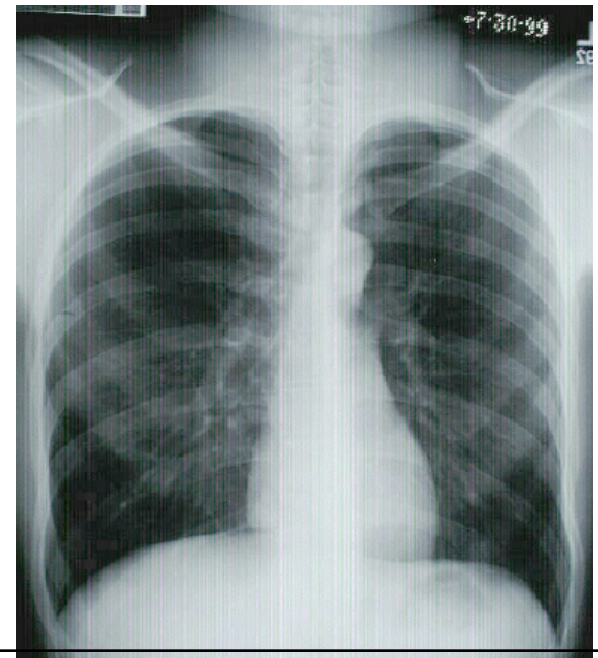
- **Bedside spirometry (PEFR, FEV₁)**
 - Measures large airway obstruction
 - Measures severity and response to therapy
 - Predicts need for admission
- **Pulse oximetry**
 - Does not aid in predicting clinical outcome
 - O₂ saturation may paradoxically drop in improving patient due to transient VQ mismatch



Asthma (7)

Diagnosis

- **Arterial Blood Gases (ABGs)**
 - Not generally indicated
 - Should not be used to determine therapy
- **Chest X-ray**
 - Not generally indicated
 - Obtain if:
 - Complications suspected (pneumothorax or pneumonia)
 - Not improving
 - Requiring admission



Asthma (8)

Asthma Phases

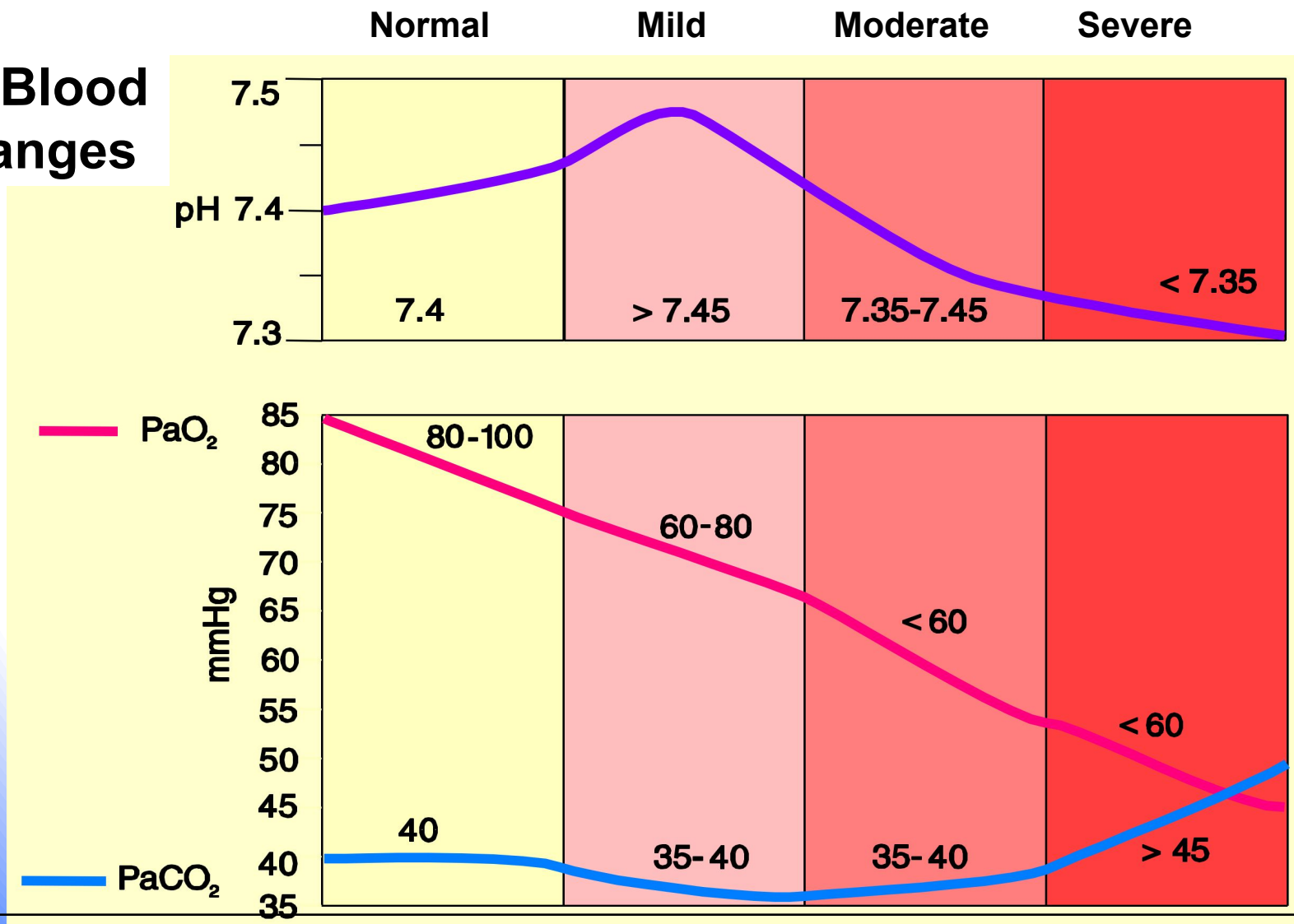
Clinical Signs

	Normal	Mild	Moderate	Severe
Respiratory Rate		↑	↑ ↑	↑ ↑ ↑ or 0
Breath Sounds		Wheezing	Unequal	Decreasing or Absent
Use of Accessory Muscles			↑	↑ ↑

Asthma (9)

Phases

Arterial Blood Gas Changes



Asthma (10)

Death Risk Factors

- Hx of sudden severe exacerbations
- Prior intubation
- Prior ICU admit
- >1 admission or >2 ED visits in past year
- ED visit in past month
- >2 adrenergic MDIs per month
- Current/recent systemic steroid use
- “Poor perceivers”
- Concomitant disease – cardiopulmonary or psychosocial
- Illicit drug use



Asthma Therapy (1)

Aerosolized β_2 agonists

- 1st line therapy
- Bronchodilators (via *adenyl cyclase*)
- Selective β_2 agonists have less unwanted β_1 effects (*tachydysrhythmias*)
- Evidence
 - Inhaled superior to oral and parenteral routes, fewer side effects
 - Intermittent equal to continuous administration
 - MDIs equal to nebulizers
 - Racemic equal to “R” enantiomer preparations (levalbuterol)



=



Asthma Therapy (2)

Steroids

- Dual Action
 - Delayed (hours)
 - **Principal Mechanism**
 - Immunomodulatory
 - Up-regulate β -receptors
 - Immediate (minutes)
 - Vasoconstriction (“Blanching Effect”)
- Evidence
 - Oral equal to IV administration
 - Systemic (PO and IV) superior to inhaled route



=



Asthma Therapy (3)

Indicated for Severe Exacerbations

- **Aerosolized Anticholinergics**
 - Ipratropium bromide (Atrovent)
 - Block tone in bronchial smooth muscle
 - Modest effect when added to β -agonists
- **Magnesium**
 - IV infusion (2-3g IV over 10 minutes)
 - Smooth muscle relaxant
 - Incremental benefit in most severe presentations



Asthma Therapy (4)

Not Indicated for Acute Treatment

- **Theophylline**
 - No benefit over β_2 agonists
 - Narrow therapeutic index
- **Long-Acting β_2 agonists** (Salmeterol)
 - Long term treatment only
- **Leukotriene modifying agents** (Montelukast) and **mast cell stabilizers**
 - Long term preventive treatment only
- **Heliox**
 - Balance of studies find no benefit
 - More convincing role in upper airway obstruction



An asthmatic patient in Ghana is successfully treated with O₂ and theophylline IV

Asthma Therapy (5)

Intubation and Beyond

- **Mechanical Ventilation**
 - Does *not* treat obstruction (e.g. the 1° problem!)
 - Barotrauma is **big** concern
- **IV Ketamine**
 - Sedation **and** bronchodilation
 - Increases secretions
- **Anesthetic gases/ECMO**
 - Transfer to the OR!



Asthma Therapy (6)

Intubation and Beyond

Preventing and Managing Barotrauma

- May use paralytics *initially* to facilitate ventilation
- Continue aggressive in-line nebulizer therapy
- Increase time for expiratory phase
(e.g. ↑ inspiratory flow rate, ↓ respiratory rate, ↓ I:E ratio)
- *Permissive hypercapnia* (allow $p\text{CO}_2$ to rise), $p\text{O}_2 > 88\%$
- Diligent *pulmonary toilet*, may need *bronchoscopy*
- External chest compression

Asthma Arrest

1 Disconnect ventilator
3 Bilateral chest tubes

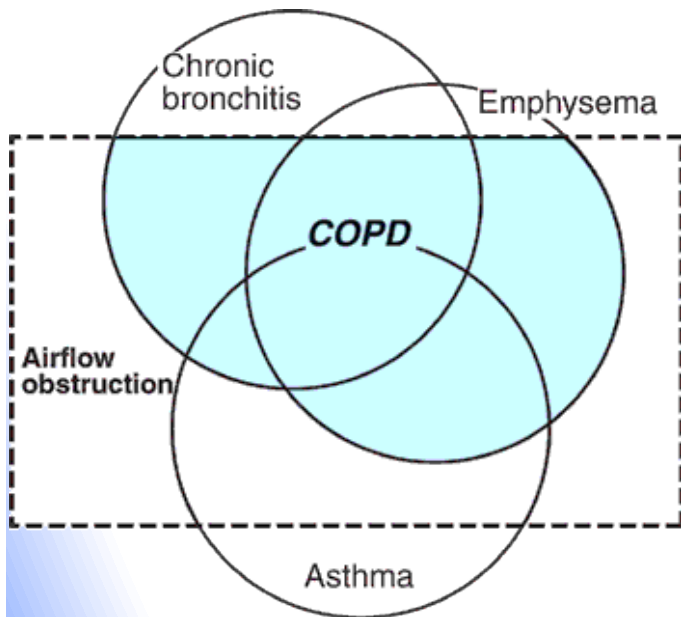
2 Compress chest
4 Fluid bolus

Bronchiolitis



- **Presentation and Diagnosis**
 - Presents like URI-triggered asthma exacerbation in small children (<2 years old, peak age=6 months)
 - Clinical diagnosis
- **Etiology**
 - Viral – usually *respiratory syncytial virus* (RSV)
 - Nasal swab for hospital epidemiology
- **Treatment**
 - Supportive, symptomatic care
 - Trial of beta-agonists
 - Steroids ineffective
 - Ribavirin for congenitally ill children

COPD (1)



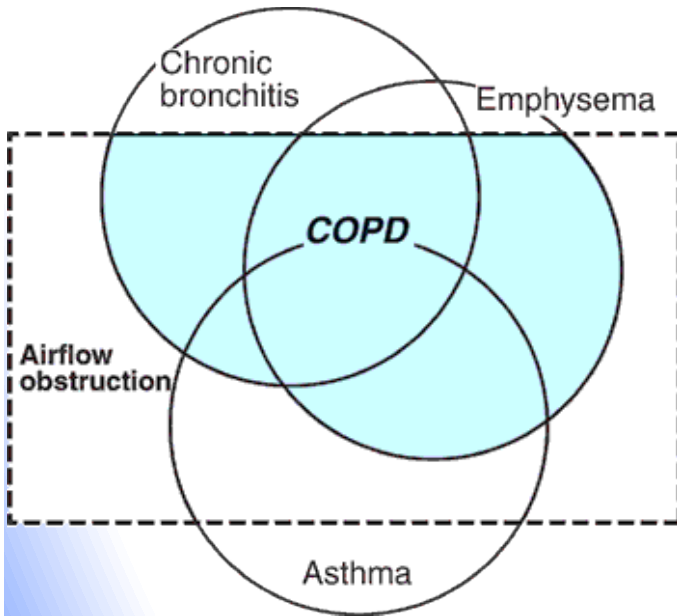
- **Definition**

- *Chronic, inflammatory* disease
- Airflow limitation that is *not* fully reversible and is progressive

- **Pathophysiology**

- *Different* inflammatory markers from asthma (e.g. neutrophils, not eosinophils)
- Proteases and oxidants result in tissue destruction

COPD (2)



• Natural History

- Hypoxemia and hypercapnia
- Destruction of pulmonary vascular bed and thickened vessel walls
- Pulmonary hypertension
- Polycythemia
- Right sided heart failure (*cor pulmonale*)

COPD (3)

Clinical Phenotypes



Blue Bloater



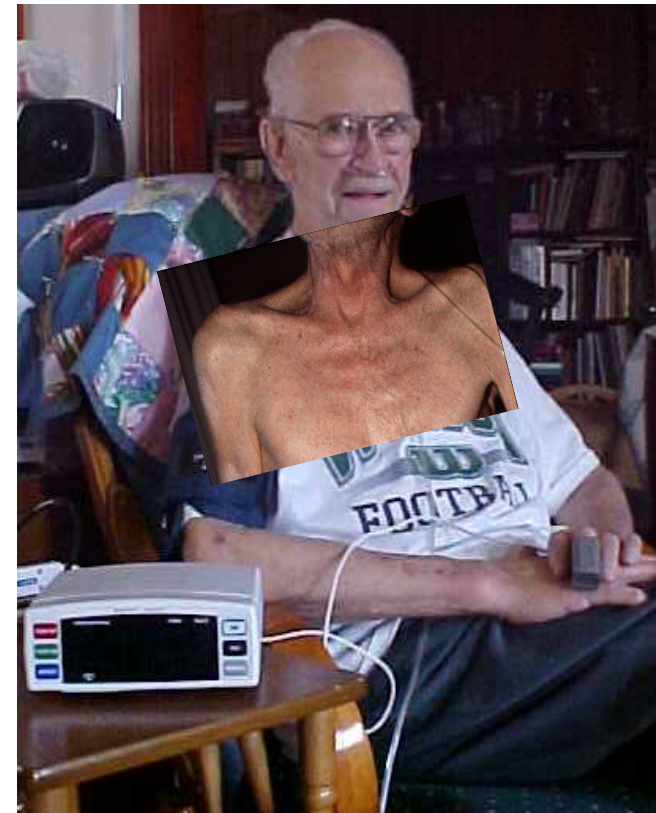
Pink Puffer

COPD (3)

Clinical Phenotypes



Blue Bloater



Pink Puffer

COPD (4)

Acute Exacerbations

- **Definition**

- ↑ Dyspnea
- ↑ Sputum volume
- ↑ Sputum purulence

- **Causes**

- Viruses
- Role of bacteria controversial
- Environmental

- **Consider *Mimics***

- Progressive onset

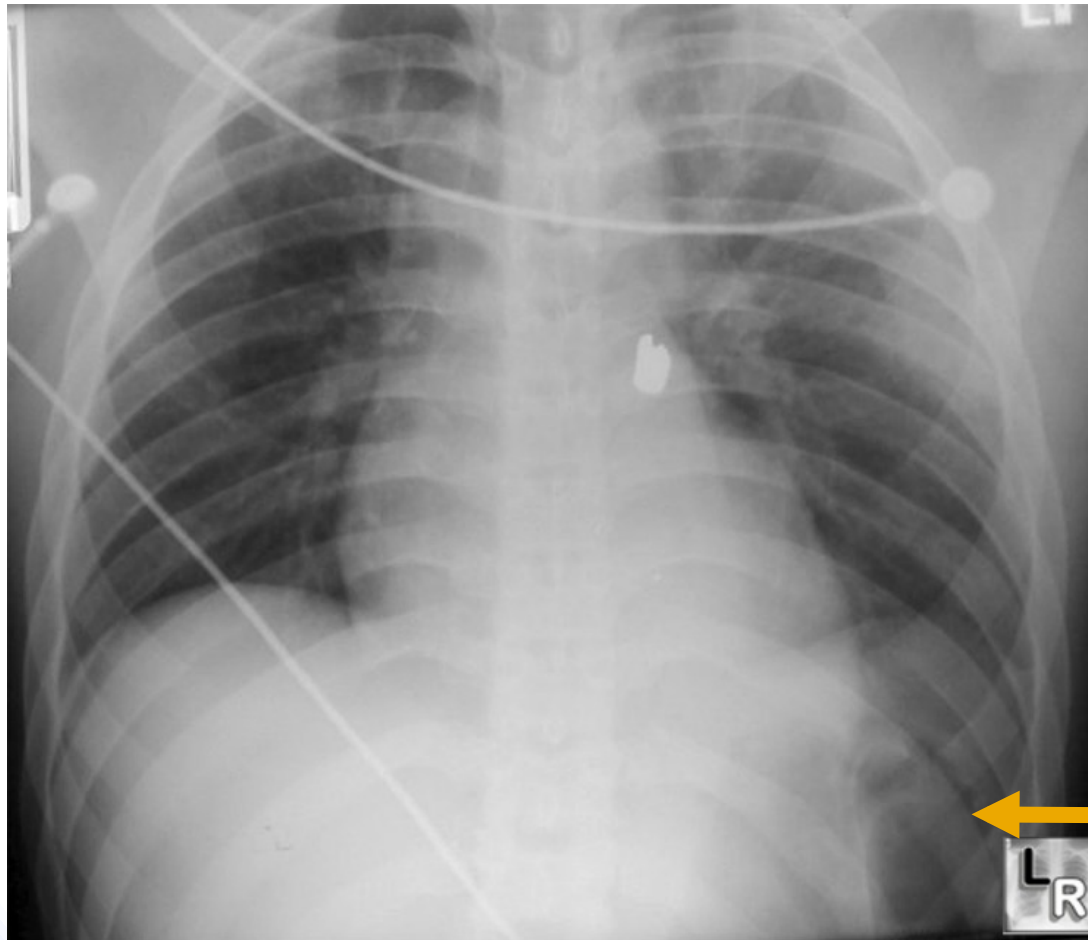
- Pneumonia
- CHF

- Sudden onset

- Pneumothorax
- PE
- Lobar atelectasis

COPD (5)

Differential Diagnosis of Acute Exacerbation



**Pneumothorax in a Supine Patient:
The Deep Sulcus Sign**

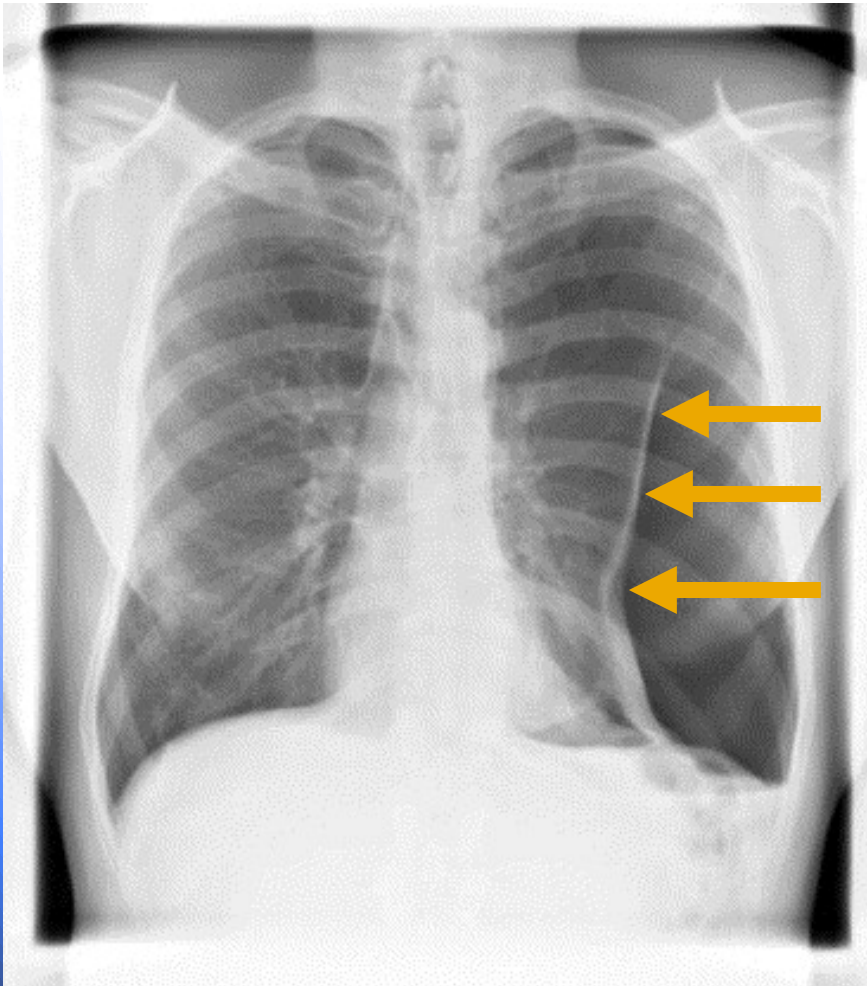
COPD (6)

CT of Anterior Pneumothorax

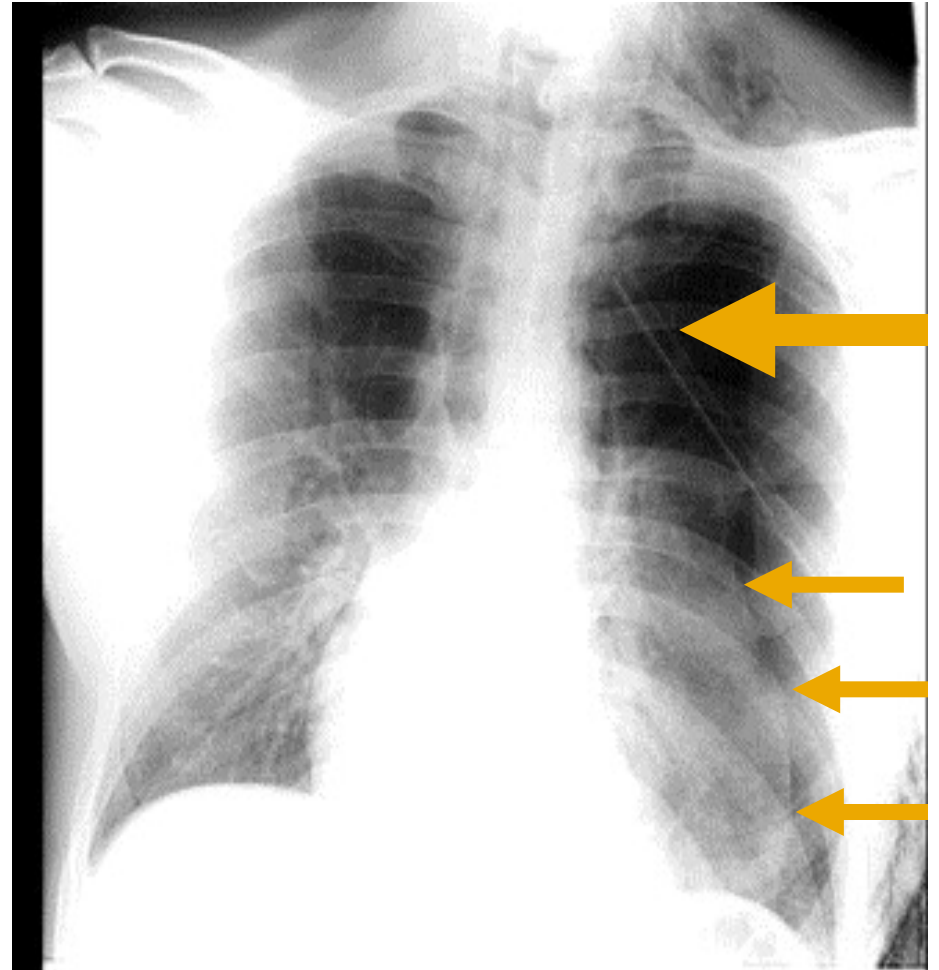


COPD (7)

Bleb Mimicking a Pneumothorax in COPD



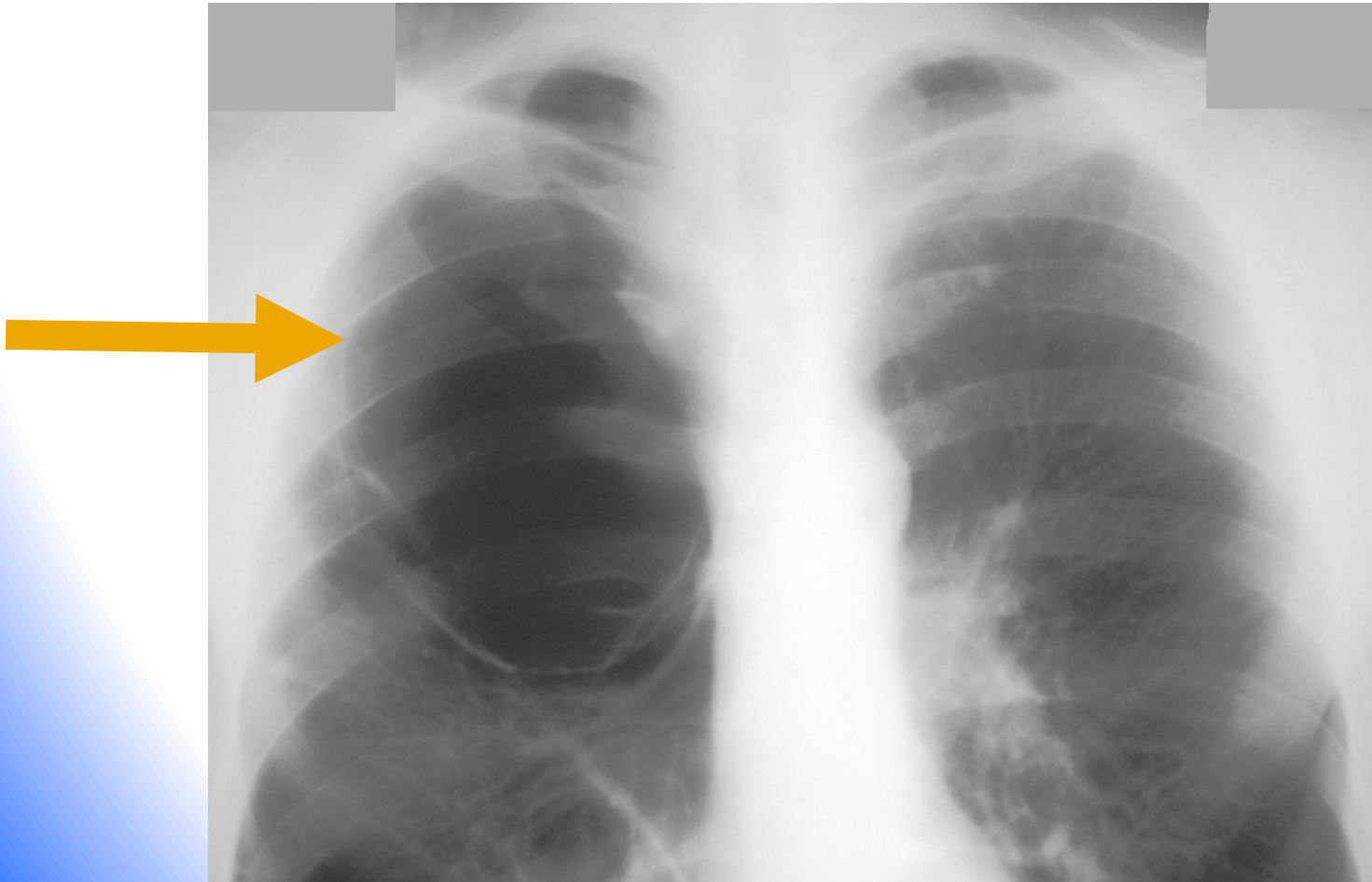
Initial Film



After Chest Tube (Oops!)

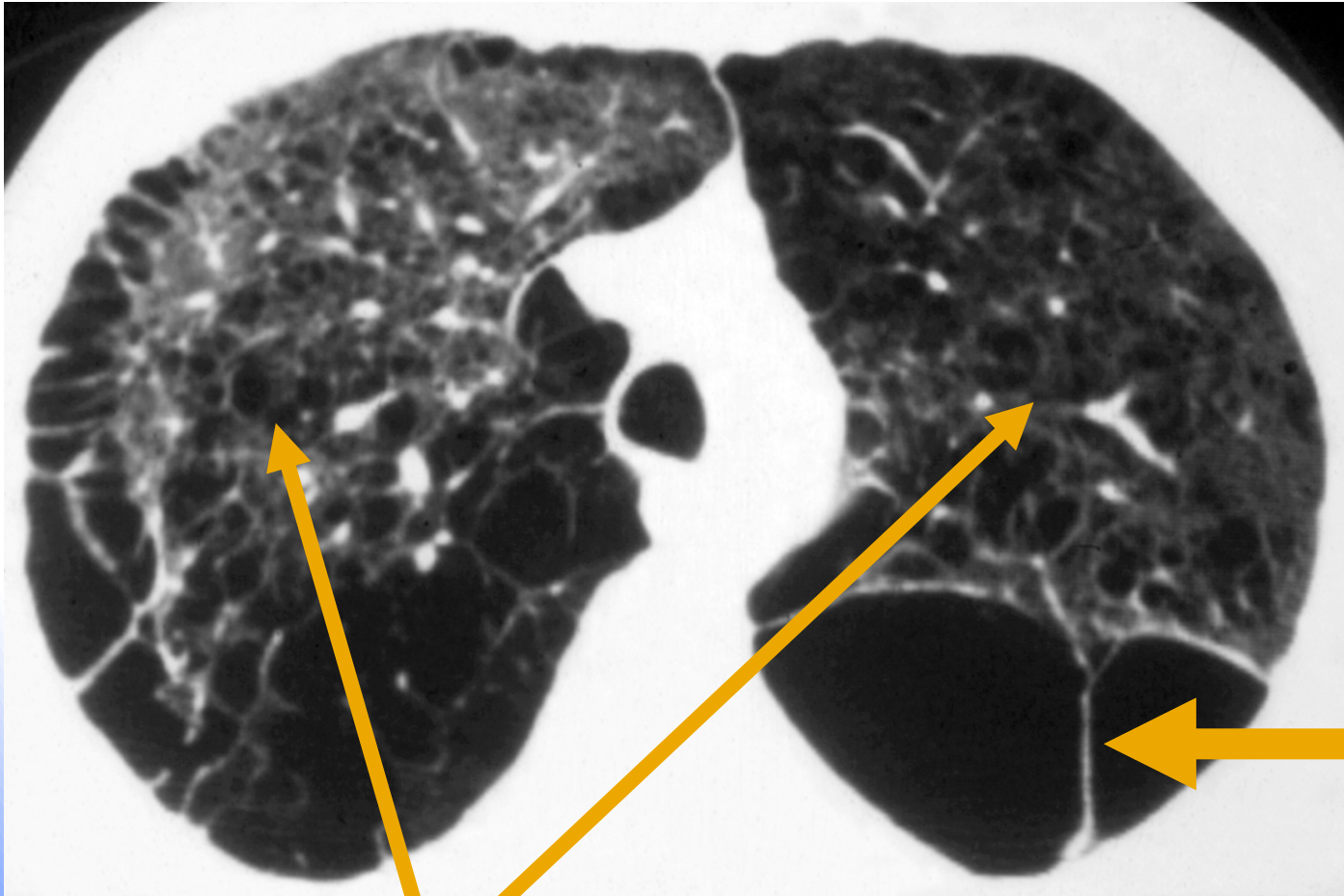
COPD (8)

Another Bleb in COPD Patient



COPD (9)

*CT Confirmation of Bullous Disease
(Pneumothorax ruled out)*

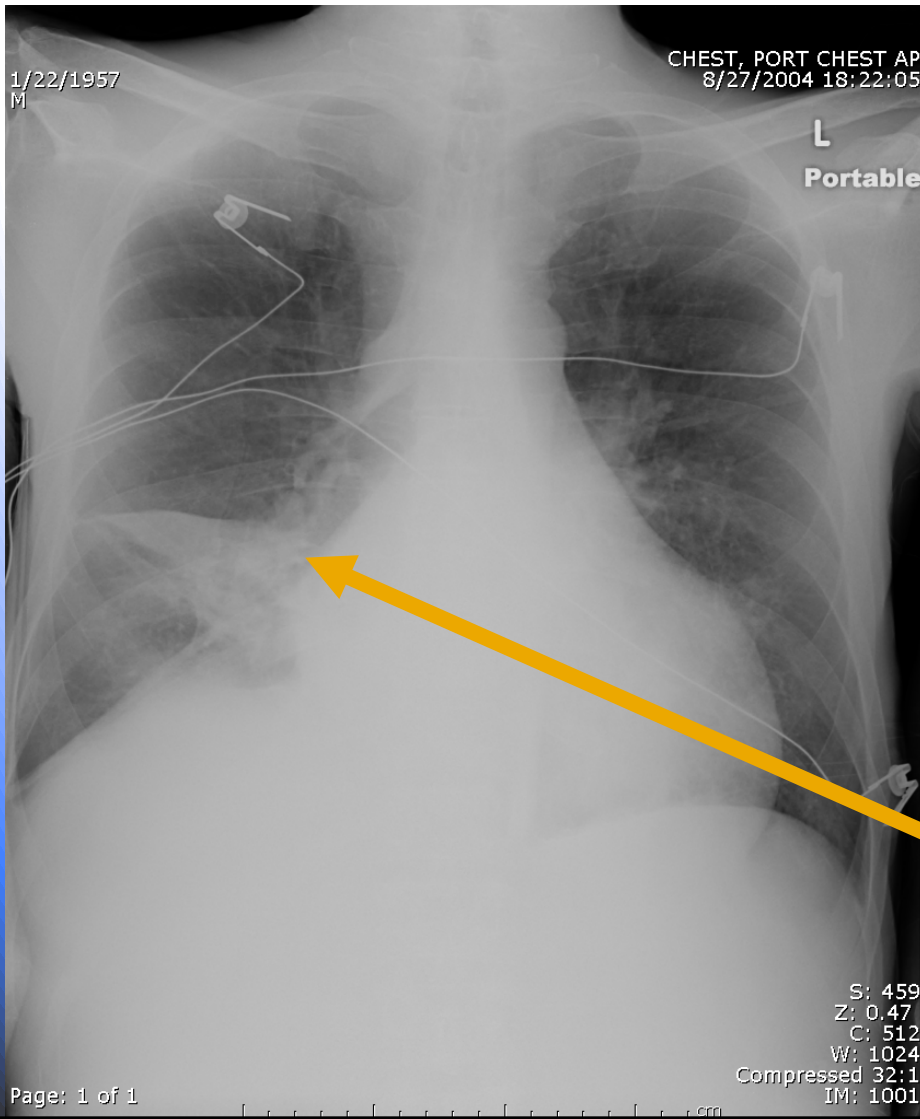


Septation
(wall of bleb)

Diffuse patchy destructive disease

COPD (10)

Lobar Atelectasis



- Sudden decompensation
- Volume loss distinguishes from pneumonia
- May require emergent bronchoscopy following intubation

**Lobar collapse with volume loss
(diaphragm pulled up)**

COPD (11)

Therapy for Acute Exacerbations

- **Aerosolized β -agonists and anticholinergics**
 - First line therapy
- **Steroids**
 - Systemic steroids (IV in ED followed by PO course) reduce rates of relapse and improve dyspnea following ED visit
- **Antibiotics**
 - Indicated in cases with \uparrow sputum volume and purulence
- **Non-Invasive ventilation**
 - Highly effective at avoiding intubation if initiated early
 - Not appropriate in patients with respiratory arrest or hemodynamic instability



Non-Invasive Ventilation

COPD (12)

Long Term Interventions

- **Disease Altering Interventions**

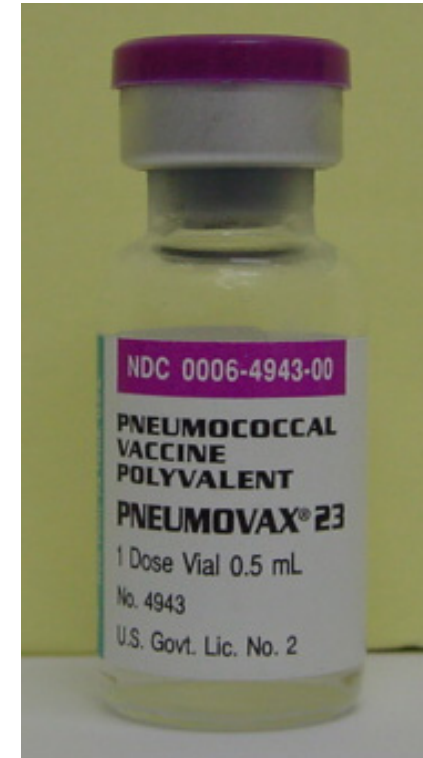
- Only 2 interventions proven to reduce mortality:

- Smoking cessation

- Home oxygen

- (for $\text{PaO}_2 < 55$ or signs of cor pulmonale)

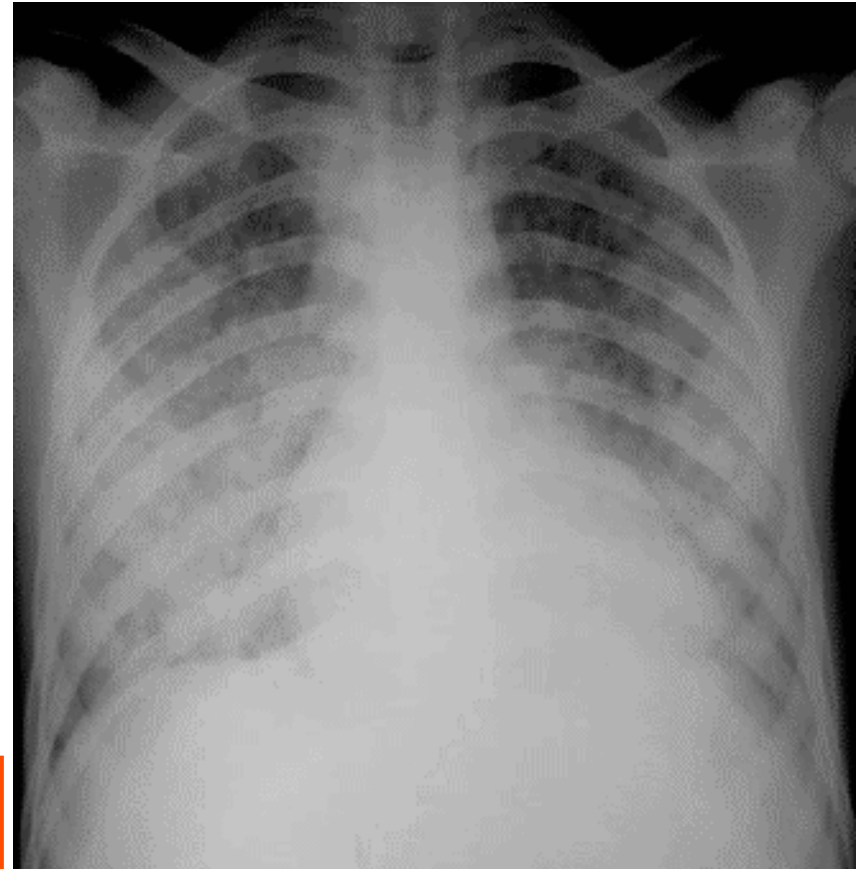
- **Pneumococcal Vaccination**



Pneumococcal Vaccine

Acute Respiratory Distress Syndrome (1)

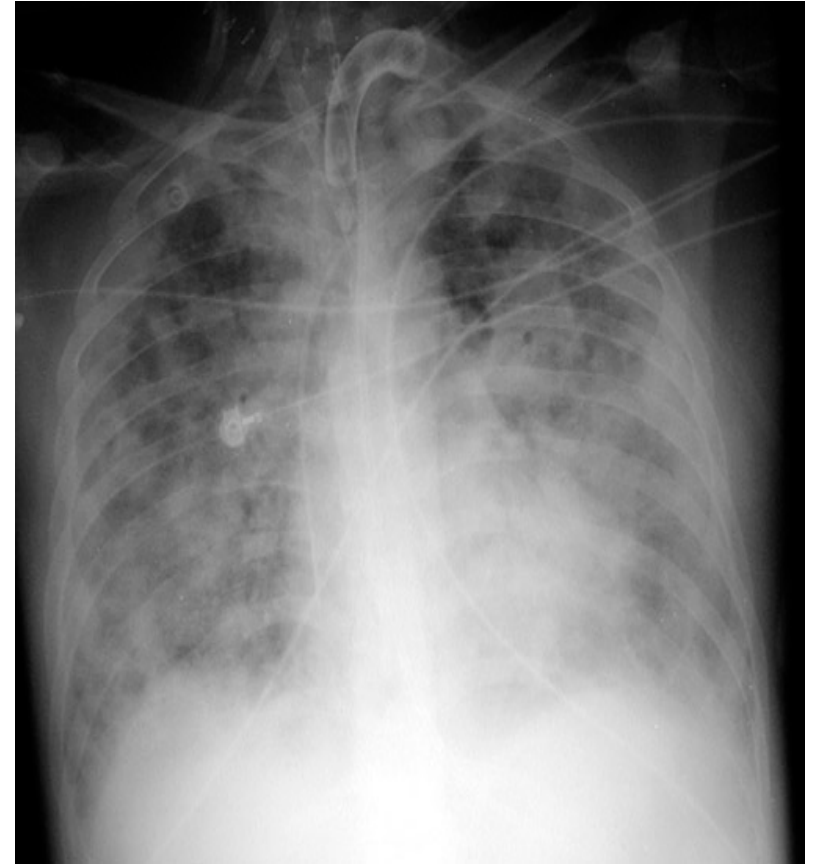
- **Definition**
 - Acute Lung Injury (ALI) and ARDS are clinical diagnoses along a spectrum
- **Pathogenesis**
 - *Noncardiogenic pulmonary edema* due to leaky alveolar capillary membranes
- **Diagnostic criteria**
 - 1 Hypoxia**
 - $\text{PaO}_2 < 60 \text{ mm Hg}$ with $\text{FiO}_2 > 0.5$
 - 2 Normal ventricular function**
 - $\text{PCWP} < 18 \text{ mm Hg}$
 - 3 Diffuse alveolar infiltrates**
 - With normal heart size



Acute Respiratory Distress Syndrome (2)

• Causes

- Sepsis (*most common*)
- Trauma
- Near-drowning
- Aspiration
- Toxicologic (ASA, opiates, hydrocarbons)
- Pancreatitis
- Environmental (high-altitude)
- Fat or amniotic fluid embolus
- CNS catastrophe (e.g. SAH)



Acute Respiratory Distress Syndrome (3)

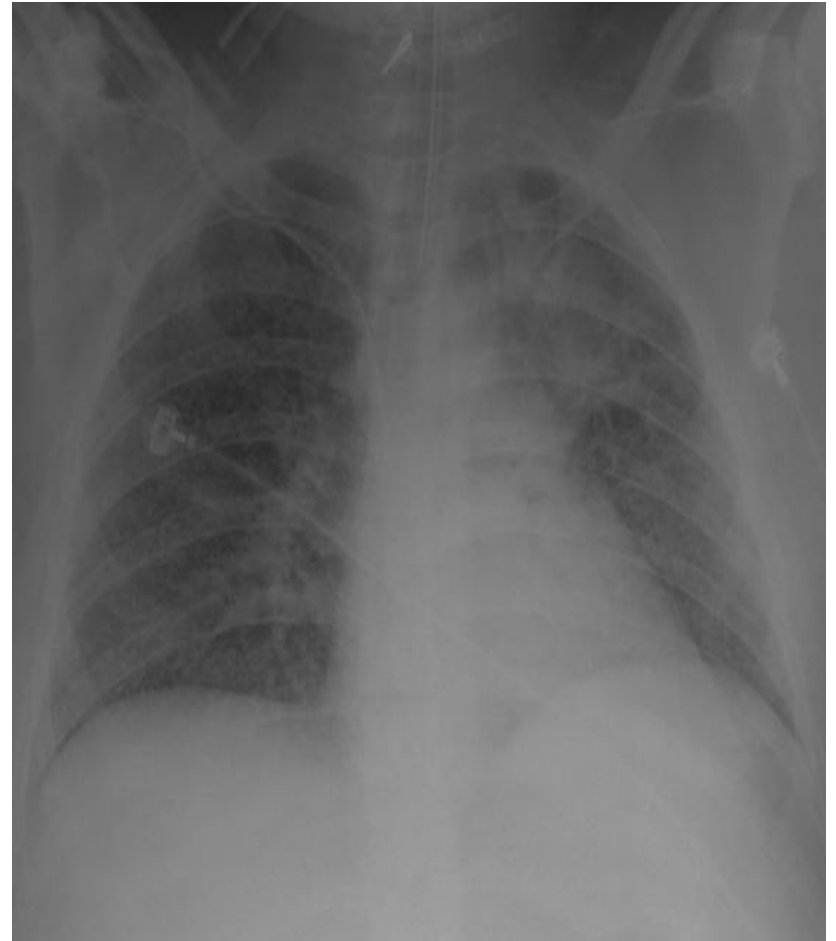
- **Treatment**

- Supportive

- Maintain O₂ sat >85% while minimizing FiO₂ and airway pressures
 - PEEP or CPAP
 - Pressure controlled or high frequency ventilation

- Recent Literature

- Lower mortality with low tidal volume ventilation (6mL/kg)
 - Prone position improves oxygenation



Pneumonia

Critical Mimics Not to Miss

- **Cancer**
- **Tuberculosis**
- **Pulmonary embolus**
- **Toxicologic / environmental**
 - Chlorine gas, Farmer's lung (allergic reaction to inhalation of moldy crops – hay, grain, tobacco)
- **ARDS**
 - e.g. from chronic ASA toxicity or other treatable cause
- **Atelectasis**
- **Right-sided endocarditis**
 - Septic emboli
- **Diffuse alveolar hemorrhage**
 - Low hemoglobin, immune disease

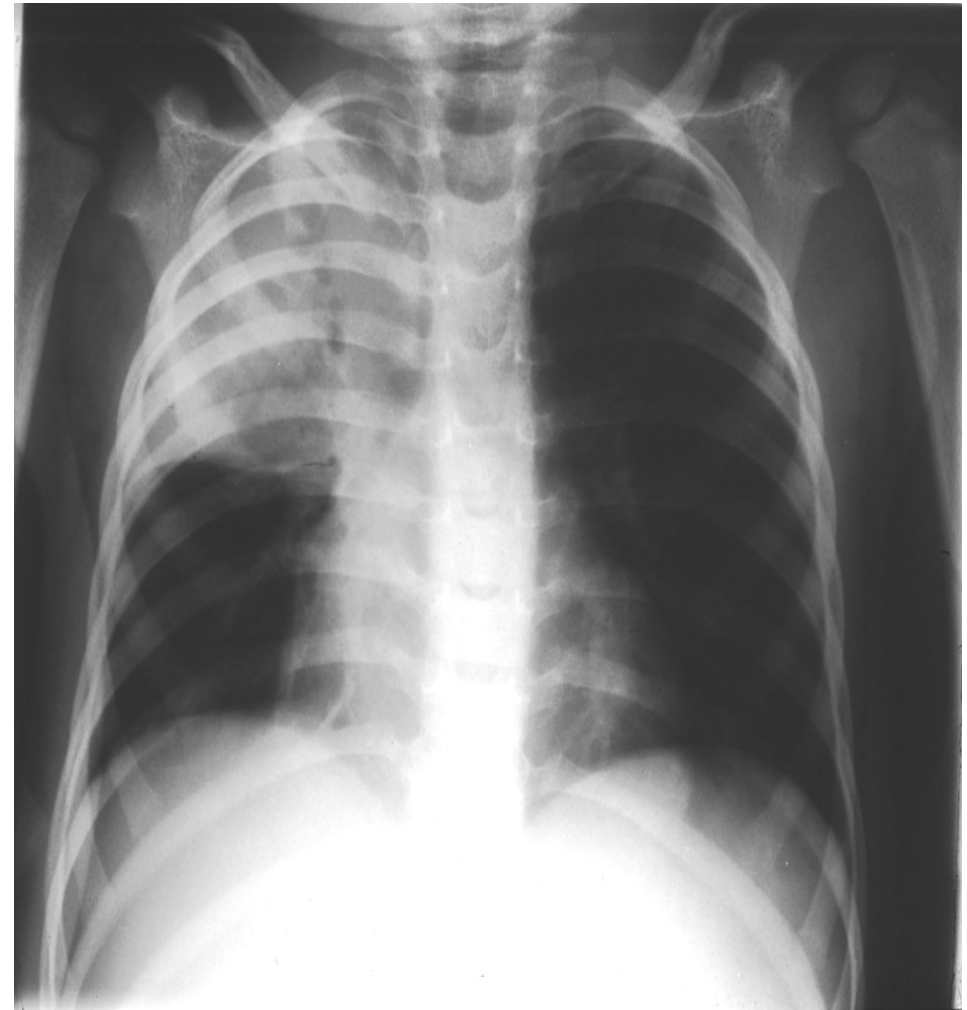
Bacterial Pneumonias

ORGANISM	TYPICAL PATTERN	TYPICAL HOST
Streptococcus pneumoniae	Lobar (Rusty sputum, Single Rigor)	Everyone Community-acquired Most common overall
Haemophilus influenzae	Lobar or patchy	COPD Smokers
Staphylococcus aureus (including MRSA)	Pleural Effusion Necrotizing (Abscesses, Cavitation, Empyema)	Post-viral IVDA
Klebsiella pneumoniae	Lobar (esp. RUL) Bulging minor fissure (Currant jelly sputum)	Alcoholics COPD, Diabetics
Pseudomonas and Enterobacter	Patchy, multilobar, necrotizing, fulminant (sickly sweet odor)	Hospital acquired Immunocompromised Cystic fibrosis
Anaerobes	Patchy (esp. lower lobes) (foul smelling sputum)	Alcoholics Poor dentition

Lobar Pneumonia



LLL Pneumonia (Pneumococcus)



**RUL Pneumonia (Klebsiella)
with bulging fissure and
abscess formation**

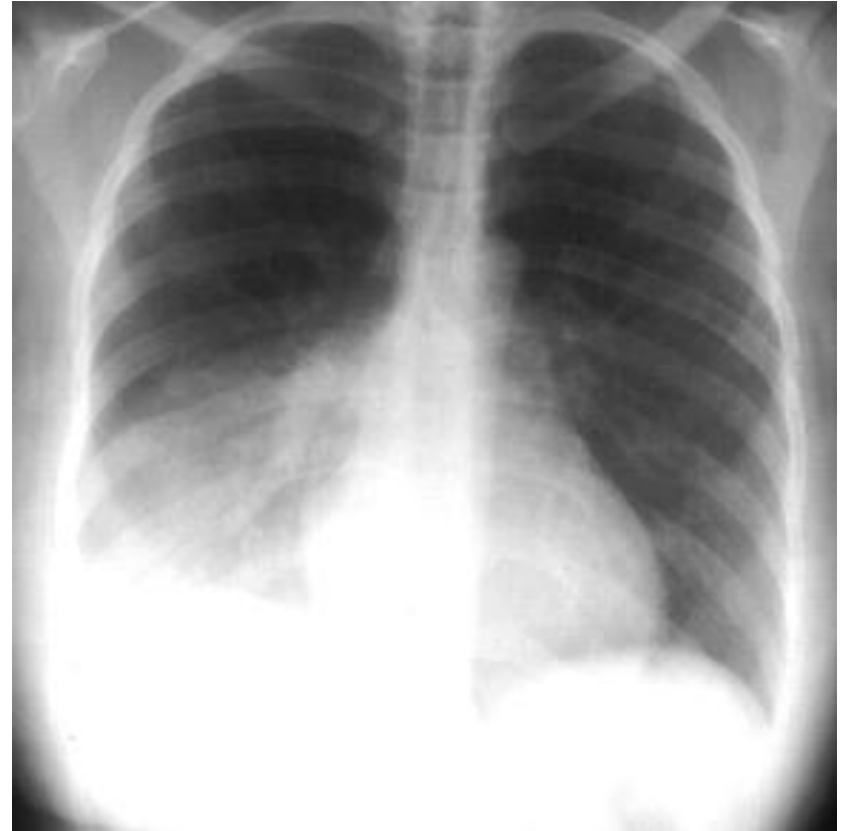
Pneumonia with Effusion

Pneumonia

- *Strep. pneumo*, *H. flu*,
Staph. aureus
- TB

Non-Infectious Effusions

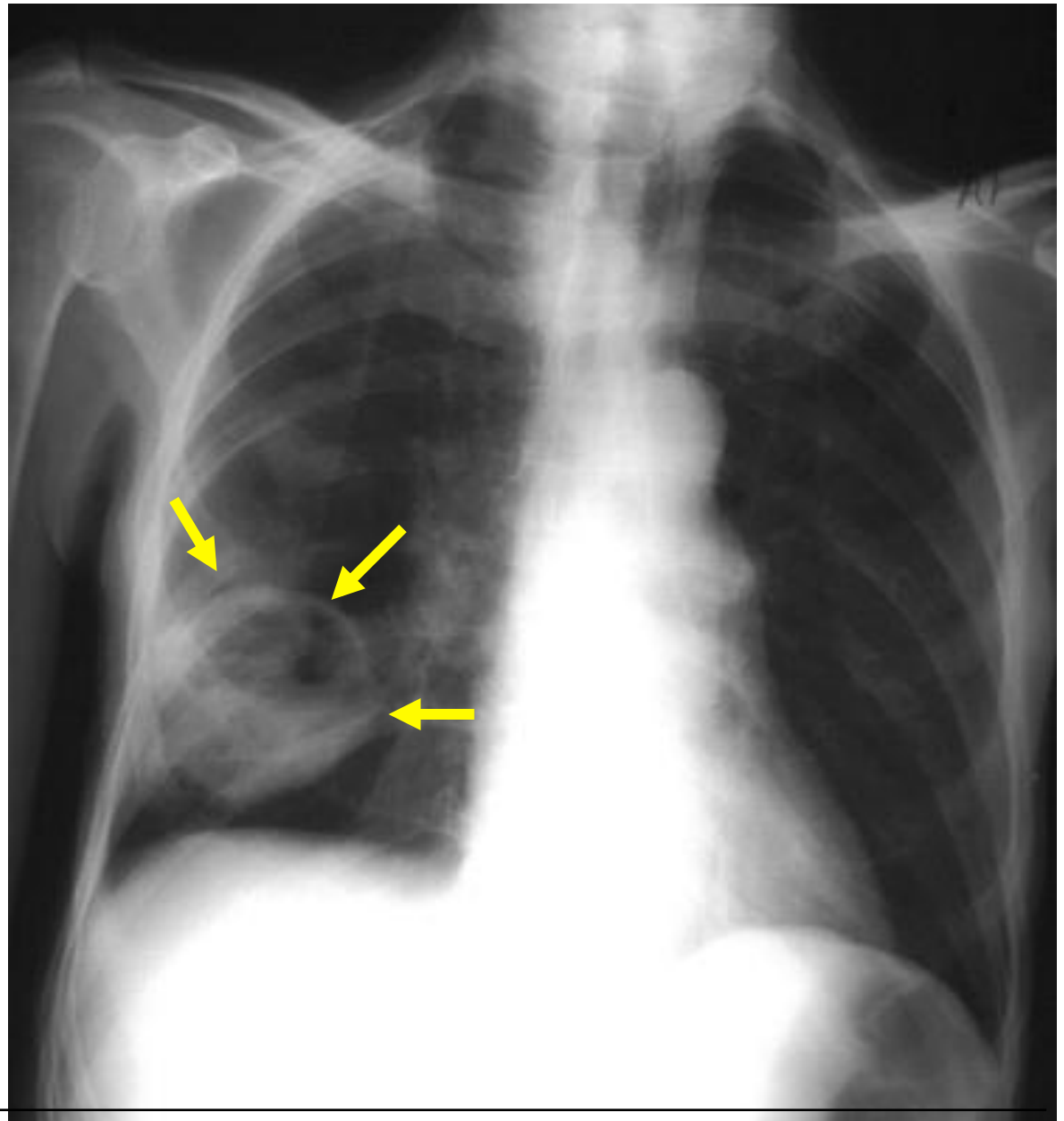
- PE
- Abdominal process
e.g. pancreatitis
- Aortic dissection
- Boerhaave's syndrome
(esophageal rupture)



Lung Cavitation

Cavities

- Staph
- Pseudomonas
- TB



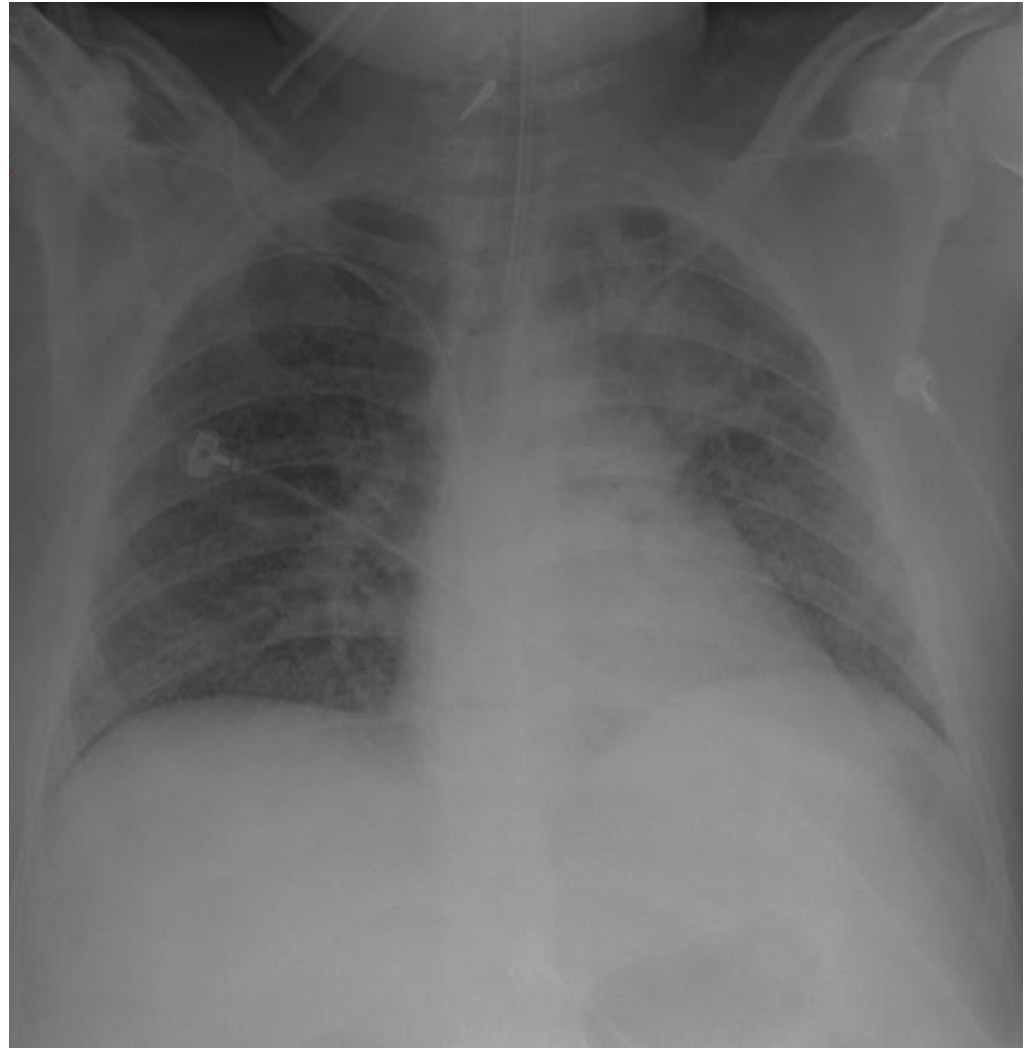
Atypical Pneumonias

ORGANISM	CLINICAL FEATURES	SPECIAL FEATURES
Mycoplasma pneumoniae	"Walking pneumonia" Young adults <u>CXR</u> : Patchy interstitial	<u>Extrapulmonary findings</u> Guillain-Barré, encephalitis, hemolysis, cold agglutinins, bullous myringitis, erythema multiforme
Chlamydia pneumoniae	Non-toxic appearing Infants at 3-20 weeks Outbreaks in young adults <u>CXR</u> : Patchy interstitial	Staccato cough Conjunctivitis (in infant group)
Legionella pneumophila	Contaminated water sources, air conditioning Older, sickly men Toxic patients, altered with relative bradycardia <u>CXR</u> : Unilateral lobar infiltrates	GI symptoms (N,V,D) Low serum sodium Abnormal LFTs No person-to-person transmission No organisms on standard smear

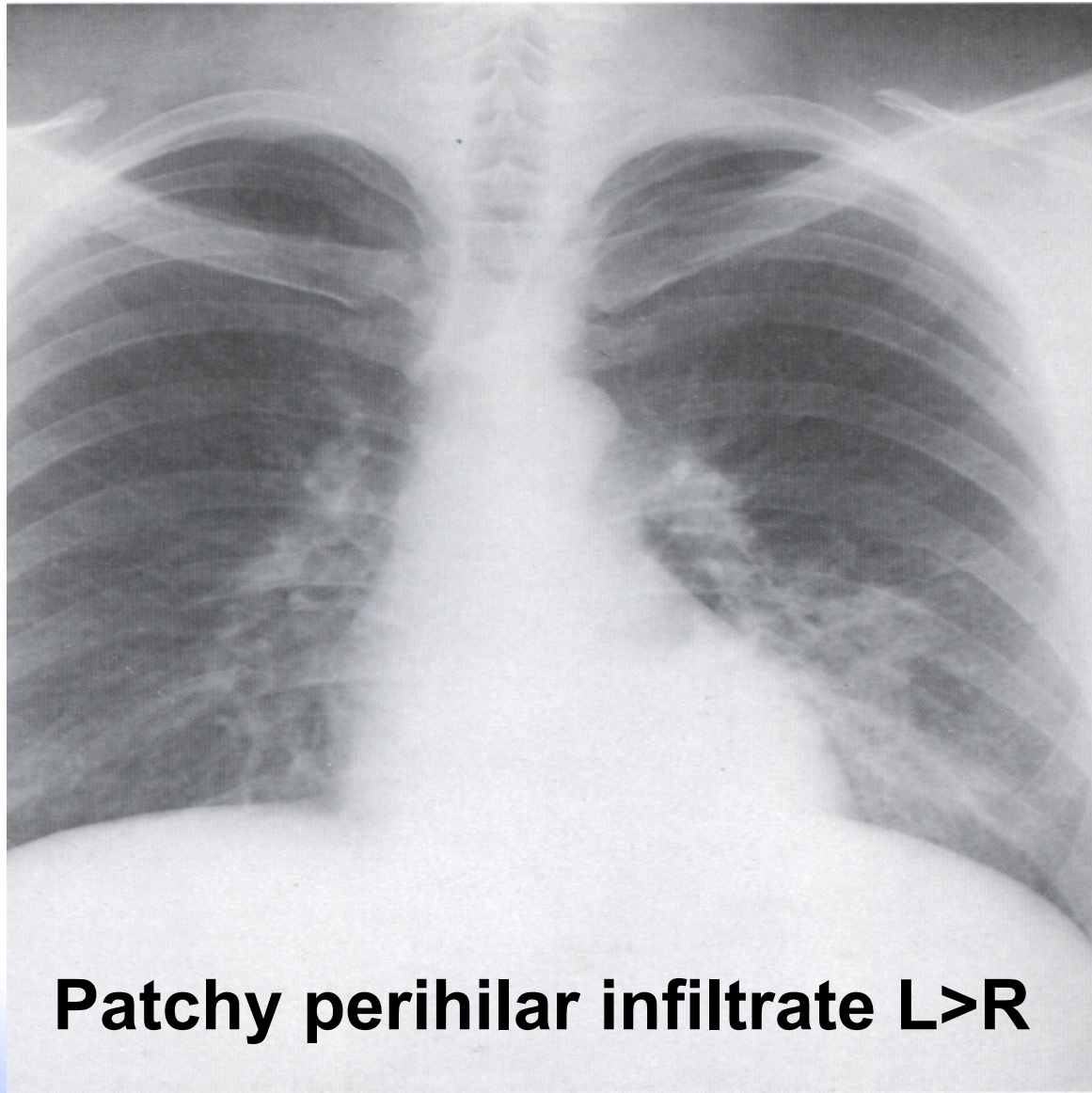
Interstitial Infiltrates

Interstitial infiltrates

- *Mycoplasma*
- *Chlamydia*
- Viral



Mycoplasma Pneumonia



Patchy perihilar infiltrate L>R

Legionella Pneumonia



X-ray in Legionella is *not* “atypical”

Really Atypical Pneumonias

ORGANISM	RISK GROUPS	CLINICAL FEATURES
Fungi	Southwest US (Coccidioidomycosis) Mississippi River Valley (Histoplasmosis) Southeast US (Blastomycosis) <u>CXR</u> : Hilar adenopathy Diffuse patchy infiltrates	Chest pain Erythema nodosum
Q fever (Coxiella burnetii)	Vets, farmers Sheep, goats, cattle <u>CXR</u> : Highly variable	Hepatitis Endocarditis
Psittacosis (Chlamydia psittaci)	Bird handlers <u>CXR</u> : Highly variable	Epistaxis Relative bradycardia Sepsis and shock Low WBC count

Fungal Pneumonia

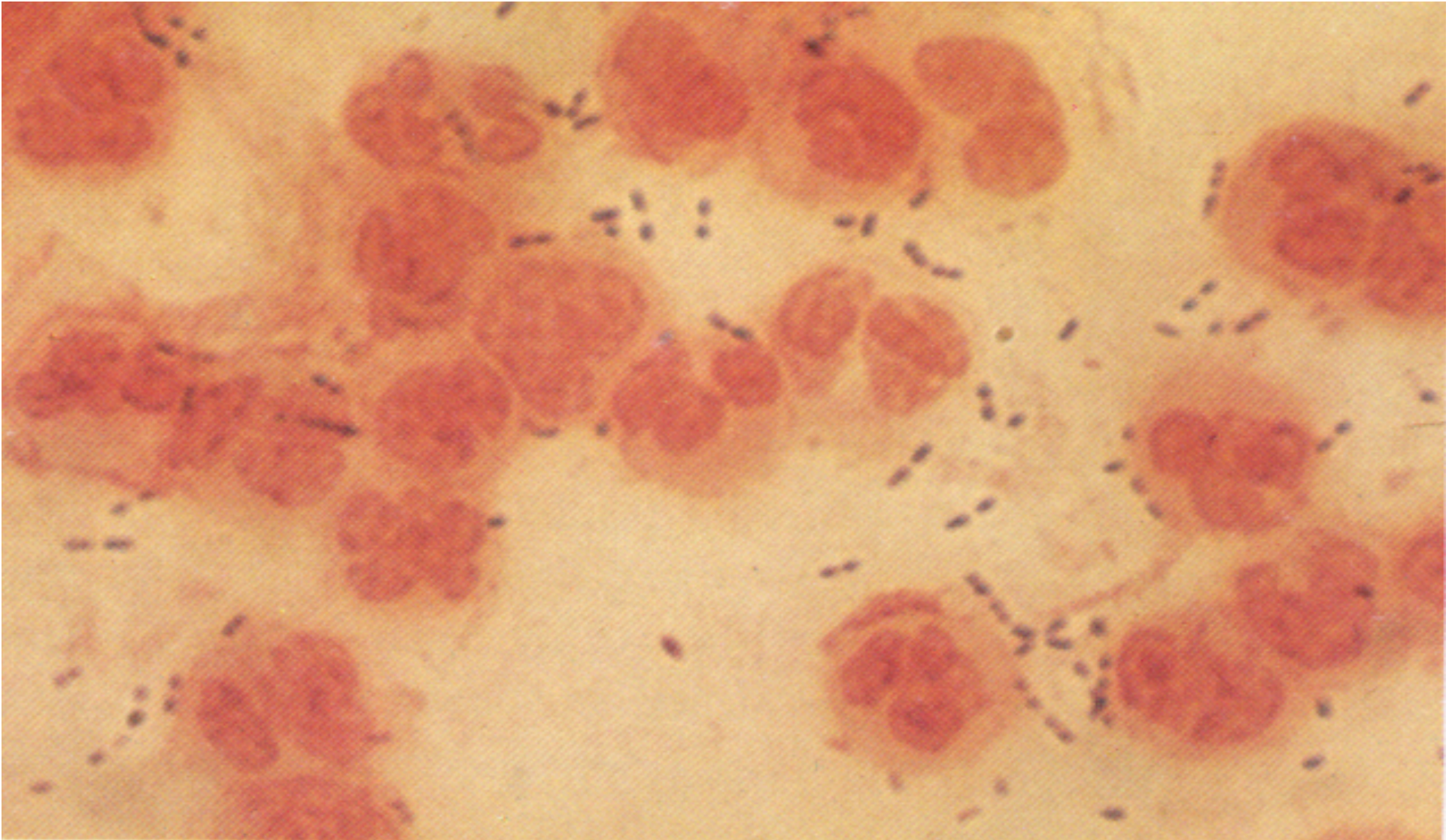


Bilateral adenopathy with patchy infiltrates

Pneumonia: Gram's Stain

● Gram's Stain	● Organism
▶ Gram positive diplococci	▶ Streptococcus pneumoniae
▶ Gram positive cocci in chains	▶ Group A streptococcus
▶ Gram positive cocci in clusters	▶ Staph. aureus
▶ Gram positive rods	▶ Bacillus anthracis (anthrax)
▶ Small Gram neg rods	▶ H. Influenza
▶ Short, fat Gram neg paired rods	▶ Klebsiella pneumonia
▶ Gram neg rods	▶ Pseudomonas, Enterobacter Yersinia pestis (plague)
▶ Intracellular, Gram negative	▶ Chlamydia
▶ No bacteria, large PMNs only	▶ Legionella
▶ No bacteria, mononuclear cells	▶ Mycoplasma

Strep Pneumoniae Sputum Gram Stain



Gram Positive Diplococci

50

Pneumonia Treatment

	<u>Organisms</u>	<u>Antibiotics</u>
Outpatient <60 years old	<i>Strep. pneumoniae</i> Atypicals	Macrolide or Doxycycline
Outpatient >60 years old	<i>Strep. pneumoniae</i> <i>H. flu</i> Gram negatives	Macrolide + Cephalosporin or Fluoroquinolone
Inpatient, Ward	Same as above	Same as above
Inpatient, ICU or Health Care Associated	Add: 1 Pseudomonas 2 Drug resistant <i>Strep. pneumo</i> 3 MRSA coverage	Antipseudomonal cephalosporin or aminoglycoside + Vancomycin

Pneumonia in Children

	<u>Organisms</u>	<u>Antibiotics</u>
Birth- 3 weeks	Group B strep E. coli Listeria monocytogenes	Ampicillin + gentamicin or Cefotaxime
3 weeks- 3 months	Strep. Pneumoniae Chlamydia trachomatis Bordetella pertussis RSV / Parainfluenza virus 3	Erythromycin or Cefotaxime
4 months- 4 years	Viruses Strep. pneumoniae Mycoplasma pneumoniae	Erythromycin or Cefotaxime
5 years- 15 years	Mycoplasma pneumoniae Strep. pneumoniae	Erythromycin/Doxycycline (>8y) or Cefotaxime (sicker)
All ages (sick)	Staph. aureus	Vancomycin

Uncommon but Deadly

- **Hantavirus pulmonary syndrome**

- In Southwest US, from aerosolized rodent excreta
- Pulmonary edema with cardiac and renal failure
- Supportive therapy only



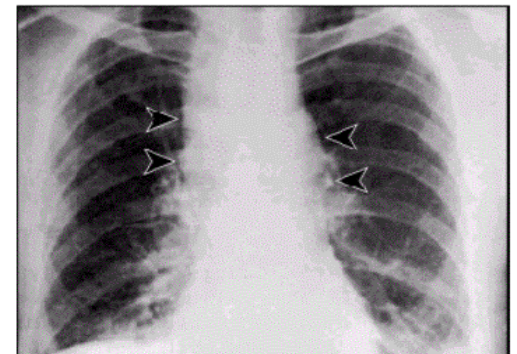
- **Plague** (*Yersinia pestis*)

- Spread by fleas on rodents (bubonic), bioterrorism (pulmonary)
- Very contagious person-to-person, strict respiratory isolation
- Bilateral, multilobar pneumonia
- Rx: **doxycycline**, fluoroquinolones, aminoglycosides



- **Anthrax** (*Bacillus anthracis*)

- Inhaled (*bioterror Class A agent*)
- No person-to-person transmission
- Hemorrhagic mediastinitis (prominent mediastinum on x-ray)
- Rx: penicillin, **doxycycline** or fluoroquinolone



Uncommon but Deadly (2)



SARS/MERS

Severe Acute Respiratory Syndrome

- Coronavirus
- **Person-to-person** spread
- Originated from civet cat in Asia (aerosolized fecal material)



AIDS: Pulmonary Manifestations (1)

- **Infectious**

Bacterial: Most common

Same pathogens as non-AIDS

Mycobacterial: TB, Mycobacterium avium complex (MAC)

Parasitic: Toxoplasmosis

Viruses: CMV, HSV

Fungal: PCP

Often disseminated

Cryptococcosis, histoplasmosis,
aspergillosis, candidiasis

- **Malignant**

- Kaposi's sarcoma

- Non-hodgkin's lymphoma

AIDS: Pulmonary Manifestations (2)

CD4 COUNT	PATHOGENS	NOTES
200+	Community acquired pneumonia (CAP) e.g. <i>H. flu</i> , <i>S. pneumo</i> Tuberculosis (TB)	Atypical CXR appearances with bacterial pathogens TB – may have minimal CXR findings
<200 (Lymphs usually <1000)	CAP, TB Pneumocystis carinii pneumoniae (PCP)	<u>PCP</u> Subacute presentation Bilateral interstitial infiltrates (<i>may be lobar</i>) Hypoxemia ↑ LDH
<50	CAP, TB, PCP Cytomegalovirus (CMV) <i>Mycobacterium avium</i> complex (MAC) Fungi (Cryptococcus , etc.)	CMV, fungi and other pathogens in end stage disease often disseminated <u>Malignancy</u> (Kaposi's sarcoma) may mimic pneumonia

PCP Pneumonia in AIDS

- **Diagnosis**

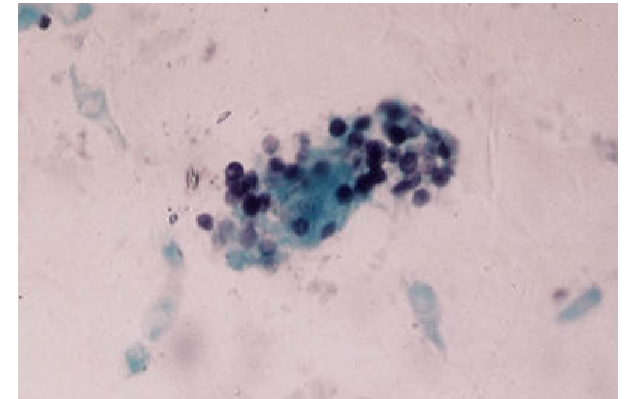
- Myriad presentations
 - Fatigue, dyspnea on exertion, “not well”
- LDH is *very sensitive* but *non-specific*
- *Clinical* Diagnosis
 - Definitive diagnosis may require bronchoalveolar lavage

- **Treatment**

- **TMP/SMX (1st line)**
 - High incidence of allergy in HIV
- **Pentamidine**
 - *IV* (watch for *hypoglycemia*, *hypotension*)
 - *Inhaled* (watch for pneumothorax)
- **Dapsone**
 - Methemoglobinemia

Steroids

- if $pO_2 < 70$ mm Hg or A-a gradient > 35



PCP on special silver stain



Classic “bat-wing” infiltrate
57

Foreign Body Aspiration

- **Children**

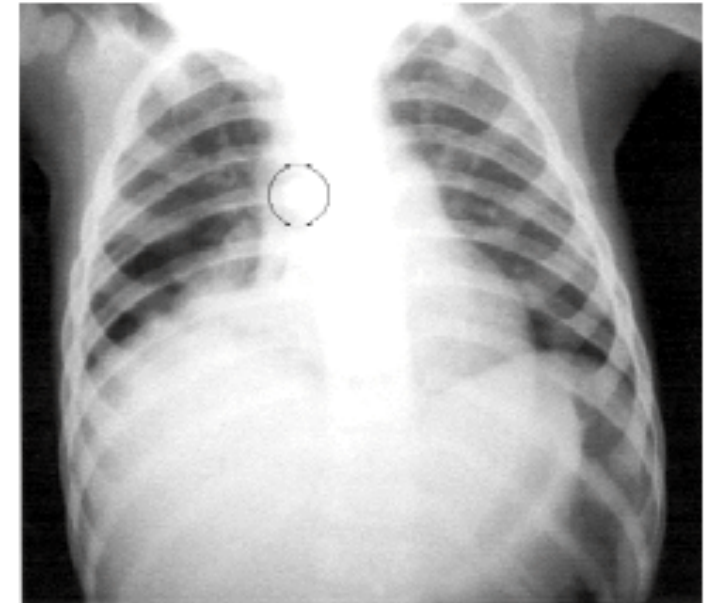
- *Foreign body aspiration should be considered when diagnosing:*

- Asthma
 - Pneumonia

- **Adults**

- *At risk for foreign body aspiration:*

- Drug and alcohol abuse
 - Mental retardation / illness
 - Neuromuscular disorder
 - Edentulousness / dental prosthetics



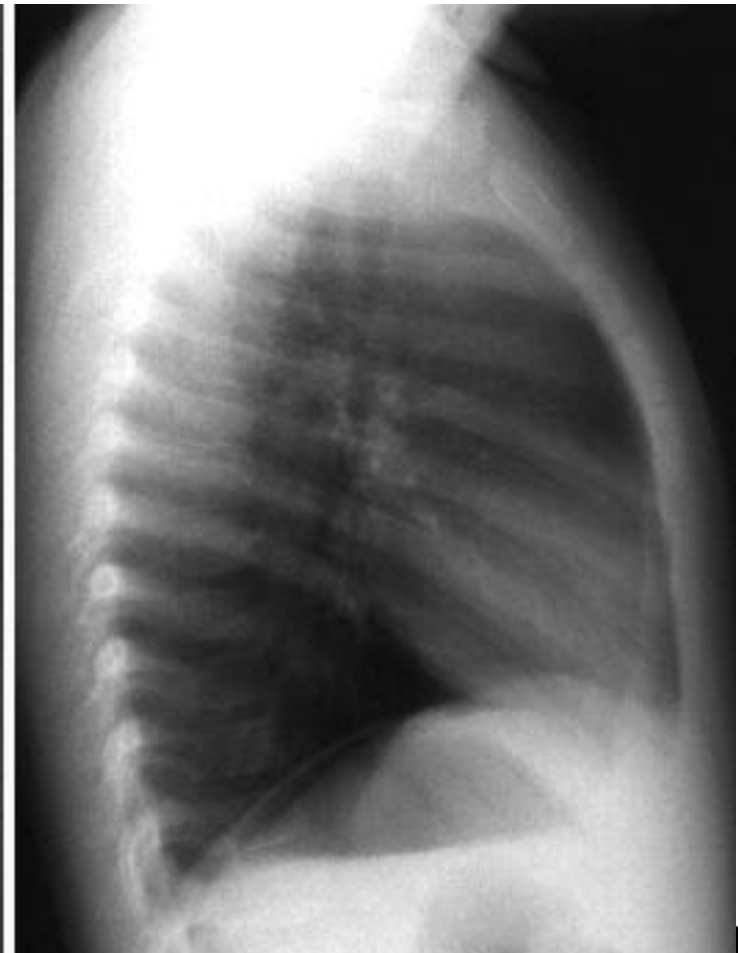
Case 1 A – First X-ray which was interpreted as pneumonia; circle shows the foreign body in the right main bronchus.

Why we miss the diagnosis

- No clear “sudden onset” of symptoms
- Improvement of symptoms with antibiotics and/or bronchodilators
- “Pneumonia” seen on the x-ray
- Negative chest x-ray
- Over-reliance on imaging – ultimately need to pursue bronchoscopy

Foreign Body Aspiration

CASE STUDY: 7 MONTH OLD CHILD COUGHING FOR 1 HR AFTER CHOKING EPISODE



Further films

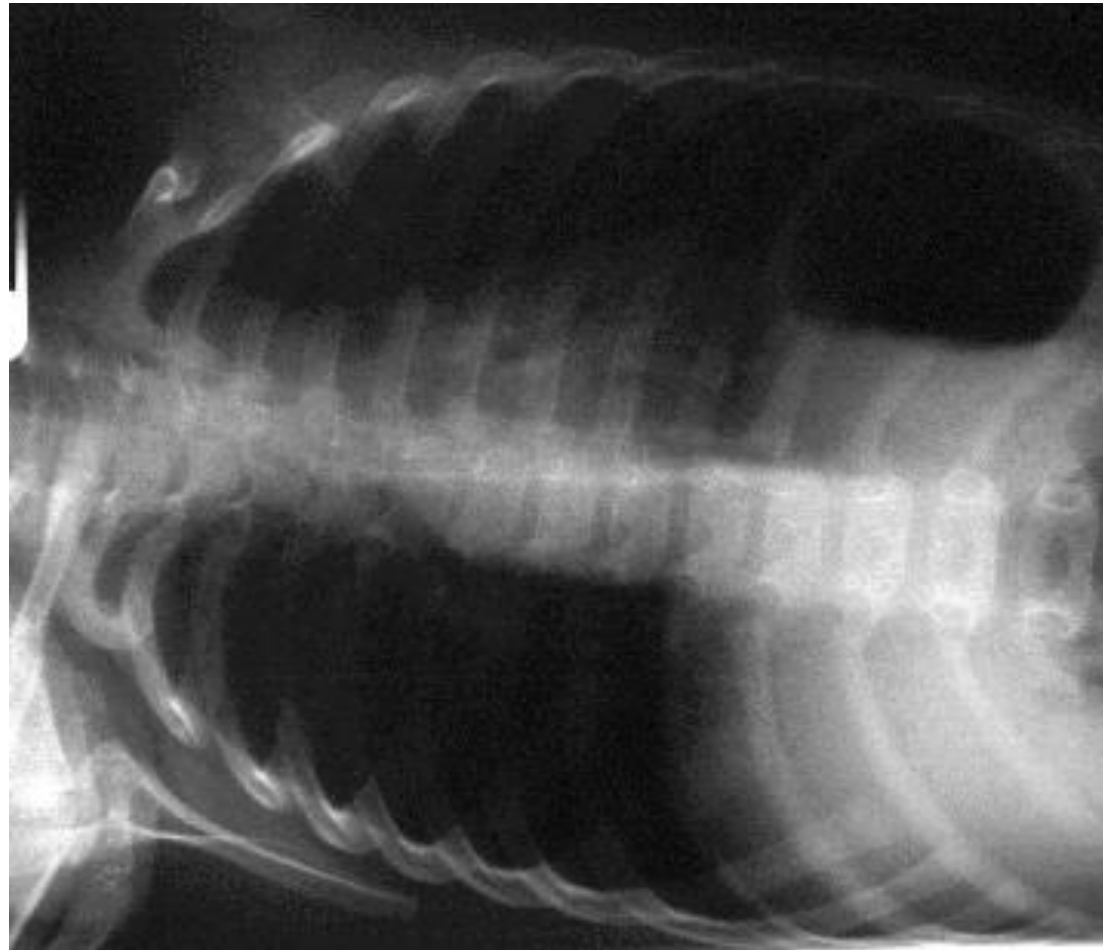
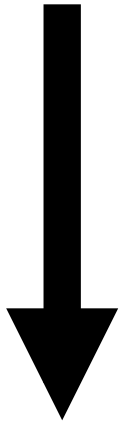


Lateral neck



Expiratory film

Further films



Failure of right lung to deflate on lateral decubitus film indicates a foreign body in the right mainstem bronchus

Aspiration Pneumonia (1)

- **Risk factors**
 - Seizure, alcoholic, obtunded, depressed gag reflex
- **Severity of syndrome depend on:**
 - pH of aspirate (lower is worse – less than 2.5)
 - Volume of aspirate (>25 mL)
 - Presence of particles such as food (bad)
 - Bacterial contamination (usually anaerobes)

Aspiration Pneumonia (2)

- **Clinical features**

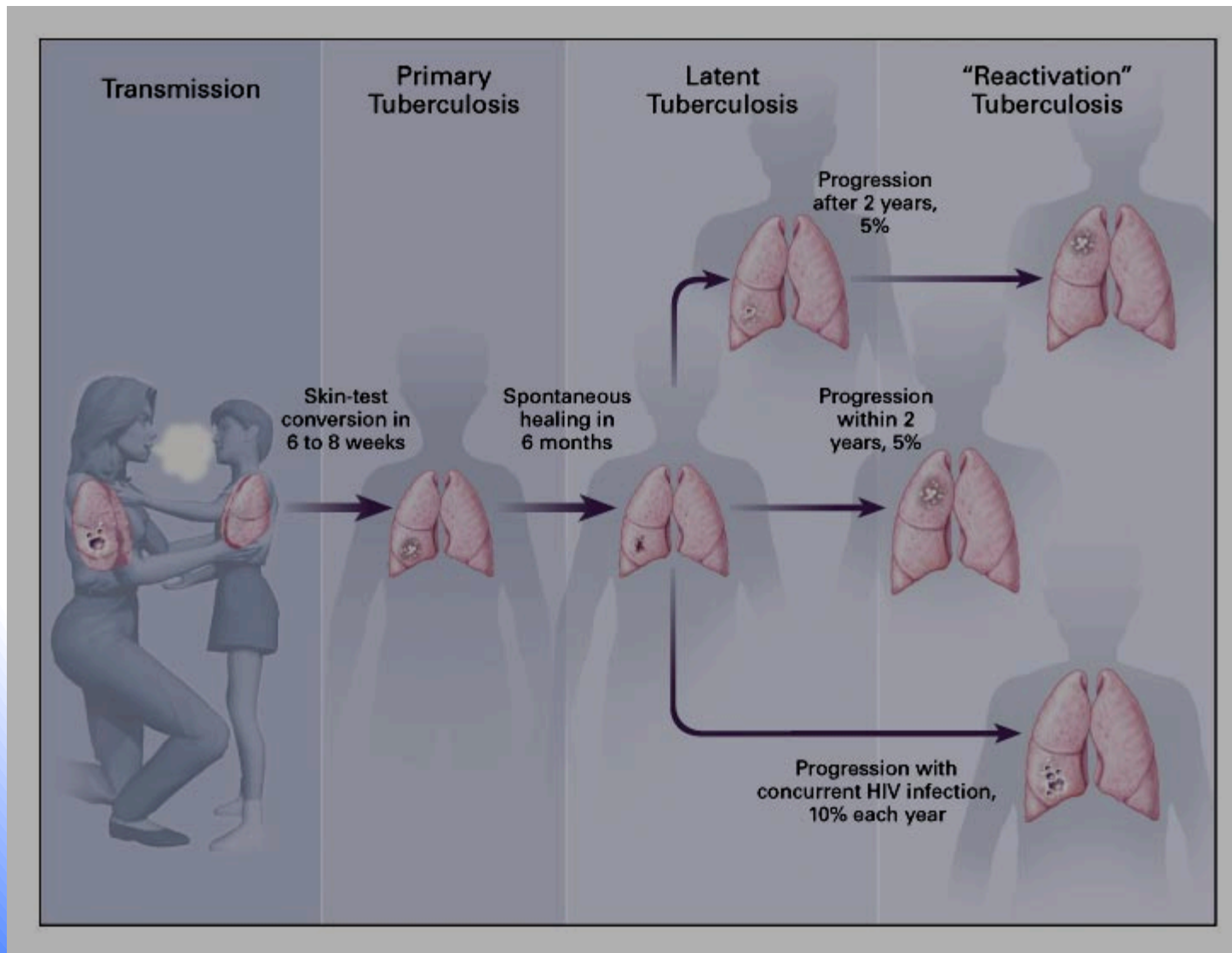
- Immediate respiratory difficulty due to chemical burn
- Hypoxemia and respiratory alkalosis
- Wheezes, rales, hypotension
- CXR often negative initially
- Localization related to dependent lung

- **Treatment**

- Supportive
- Hold antibiotics until febrile to avoid selecting out resistant organisms

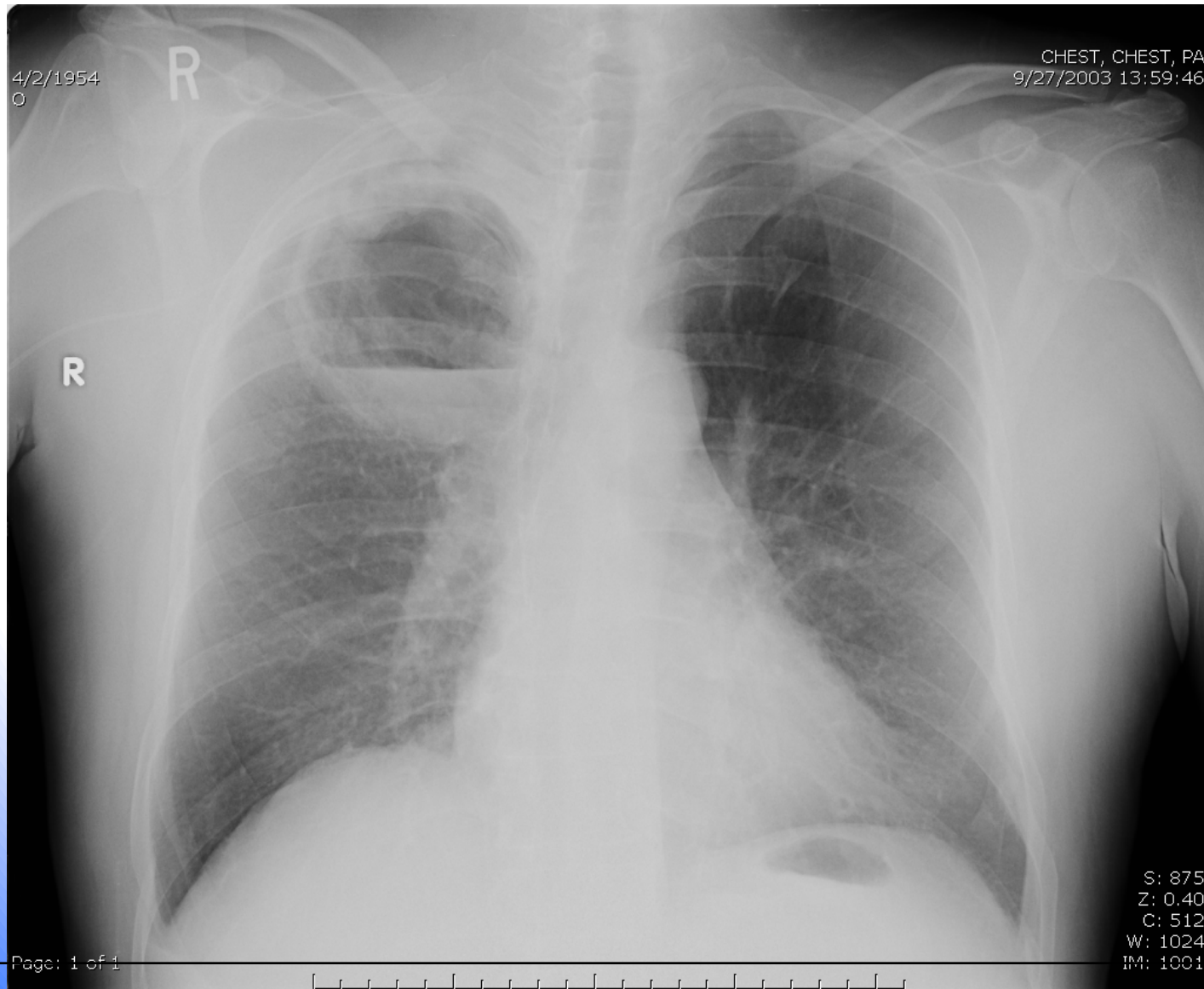
Tuberculosis (1)

Natural History



Reactivation Tuberculosis

Cavitary Lesion RUL



Miliary Tuberculosis (Hematogenous)

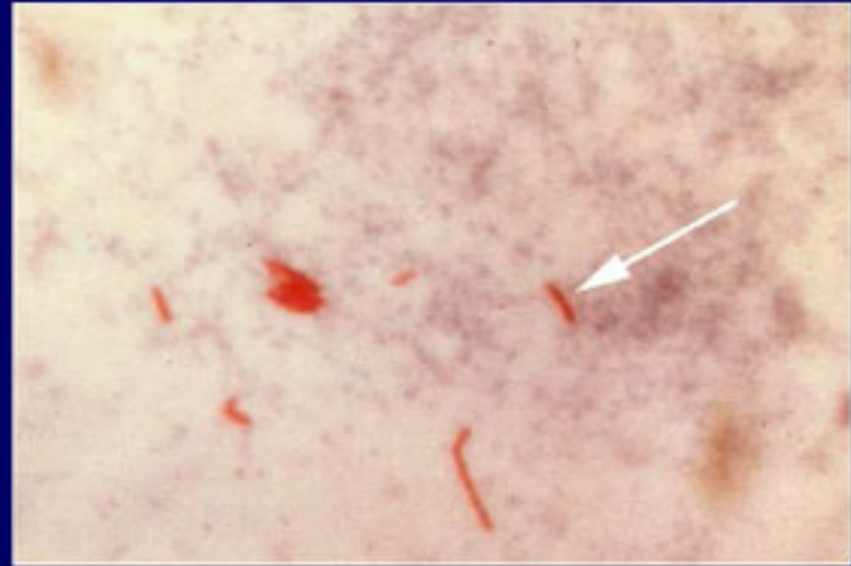


Tuberculosis (2)

ED Diagnosis

- 50-80% of patients with pulmonary TB will have positive smears
- Sensitivity ~ 60%
- AFB NEGATIVE
Not helpful in suspicious cases

AFB smear



AFB (shown in red) are tubercle bacilli

Tuberculosis (3)

Treatment Side Effects

- **Hepatitis**
 - Isoniazid (INH), Rifampin (RIF) and Pyrazinamide (PZA)
- **Peripheral Neuropathy**
 - Isoniazid (INH)
- **Optic neuritis**
 - Ethambutol (EMB)
- **Gout**
 - Pyrazinamide (PZA)
- **Ototoxicity and renal toxicity**
 - Streptomycin and other aminoglycosides
- **Discolored body fluids**
 - Rifampin (reddish-orange urine, feces, saliva, sweat, tears)

Tuberculosis (4)

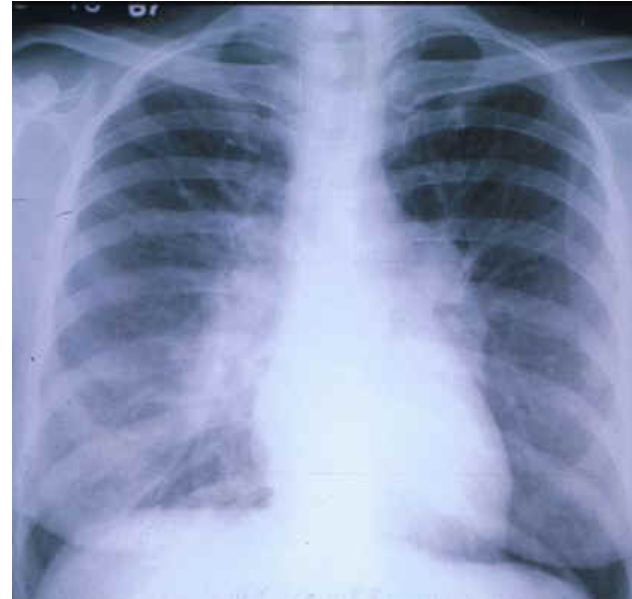
TB Skin Testing

Interpretation of PPD Skin Test Results

- Positive-predictive value of PPD skin test is dependent on the prevalence of TB infection in the population tested
- Different cut-points are used depending on the risk of TB infection in the population being tested:
 - >5mm for highest risk groups
 - >10mm for persons with other risk factors
 - >15mm for persons with no known risk factors

Sarcoidosis

- Non-infectious, non-caseating multi-system granulomatous disease
- Most prevalent in African-American adult women
- Bilateral hilar adenopathy, pulmonary infiltrates, ocular and skin lesions
- Asymptomatic through cough, SOB, eye pain, fever, night sweats
- Anemia \uparrow Ca $^{2+}$ \uparrow ALP
- Treat cardiac, CNS, ocular complications with steroids



Bilateral hilar adenopathy



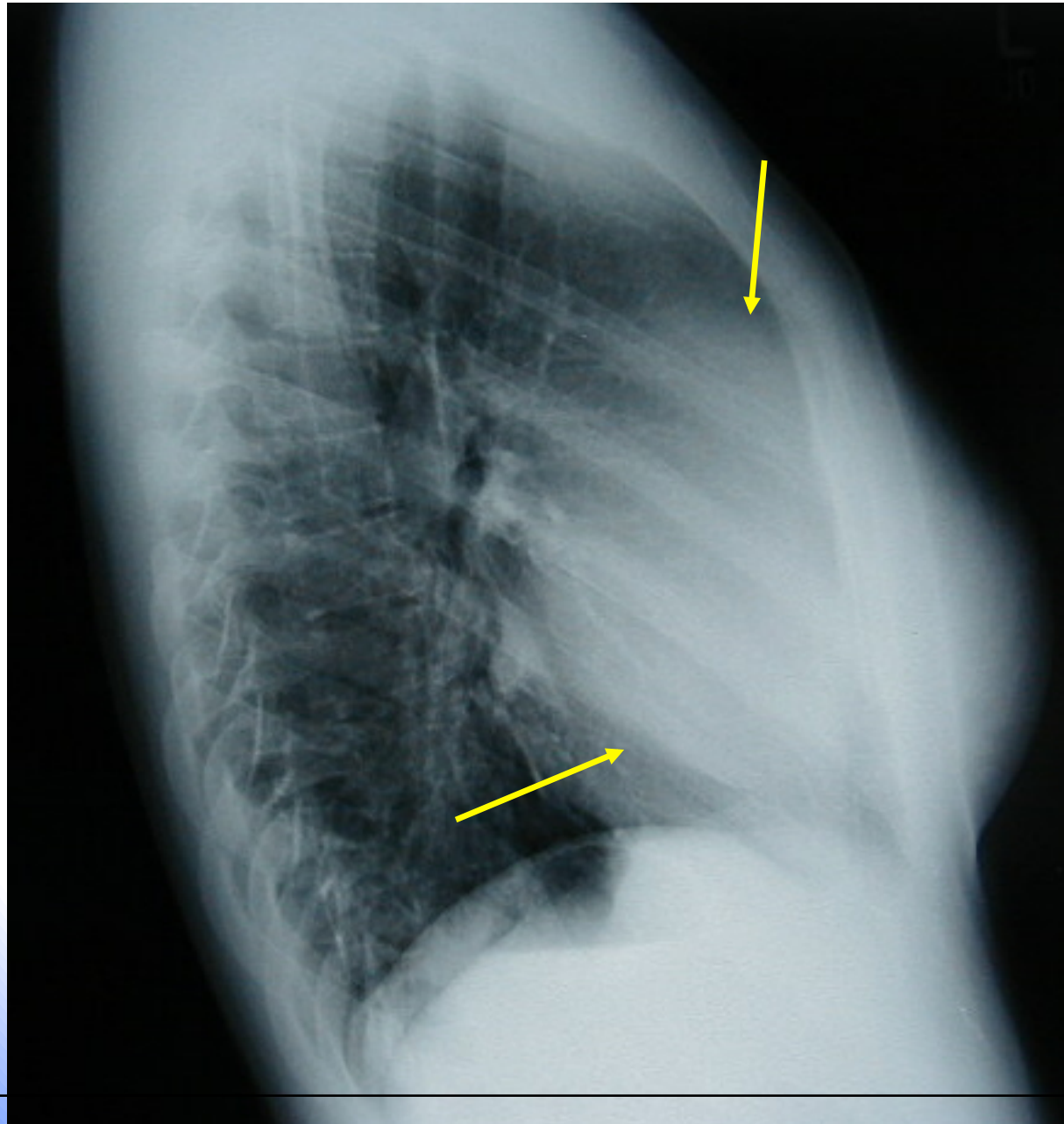
Sarcoid skin lesions

Mediastinal Masses

- Mediastinum divided into anterior, middle, posterior compartments
- Anterior: from sternum to anterior pericardium
- Mass in anterior mediastinum: five “T”s
 - Thymoma (consider myasthenia gravis)
 - Thyroid (retrosternal)
 - Teratoma (teeth, hair, etc.)
 - T cell lymphoma
 - “Terrible” (carcinoma)

Bronchogenic CA most common mediastinal mass

Anterior Mediastinum Mass (Thymoma)



Superior Vena Cava Syndrome



- **Definition**
 - Obstruction of SVC with resultant engorgement and edema of face and arms
- **Presentation**
 - Headache (increased intracranial pressure), plethoric facies, visual changes, syncope, dyspnea
- **Treatment**
 - SVC stenting (interventional rads)
 - Radiation / chemotherapy therapy for malignant causes

Spontaneous Pneumothorax



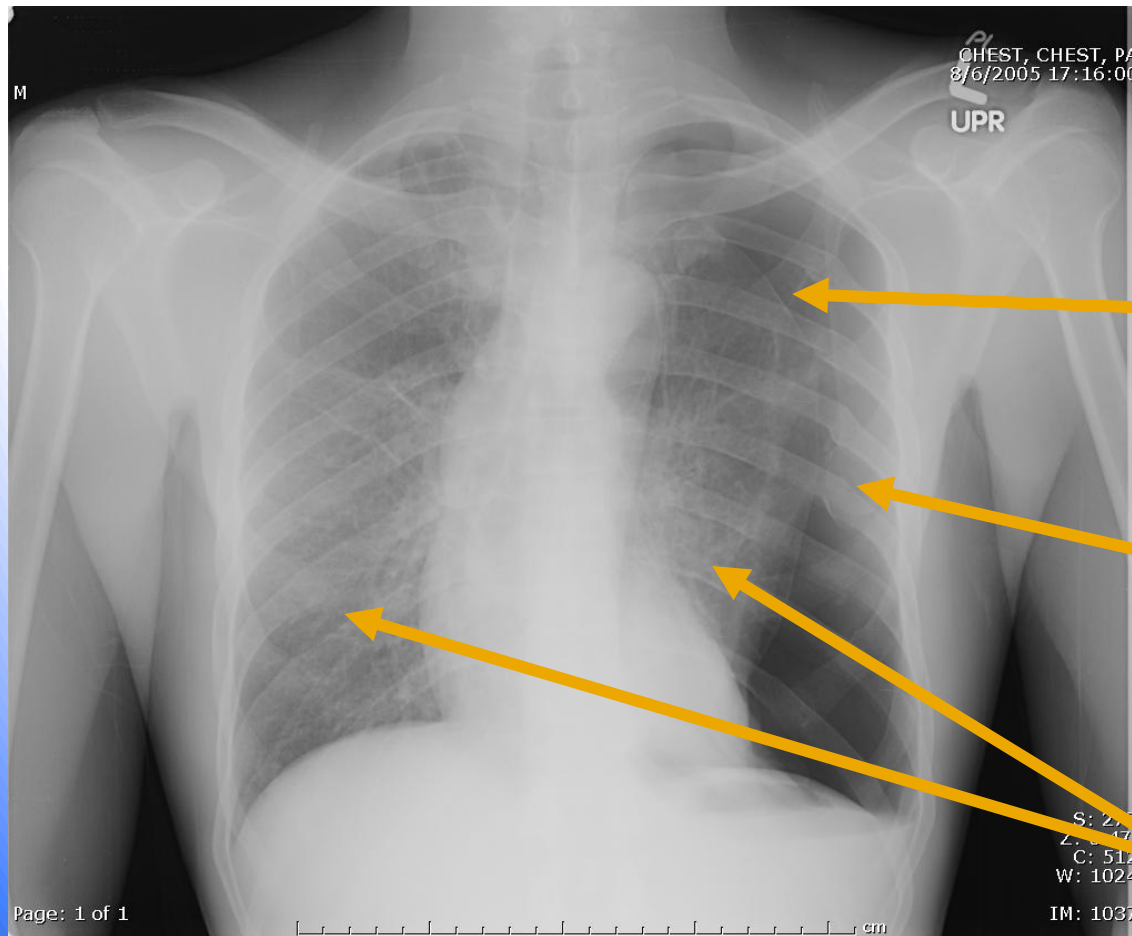
- **Causes**

- Primary (tall, thin men)
- Valsalva or Muller maneuver (drug smokers)
- Asthma, COPD
- Neoplasm
- Marfan's, Ehlers-Danlos
- Cystic fibrosis
- Pneumonia
- Catamenial: associated with menstruation (endometriosis-related)

- **Treatment Options**

- Observation, high flow O₂
- Mini-catheter aspiration
- Heimlich flutter valve
- Formal chest tube
 - ***Patient on ventilator requires chest tube***

Pneumothorax



Upright PA View

Visceral pleural line

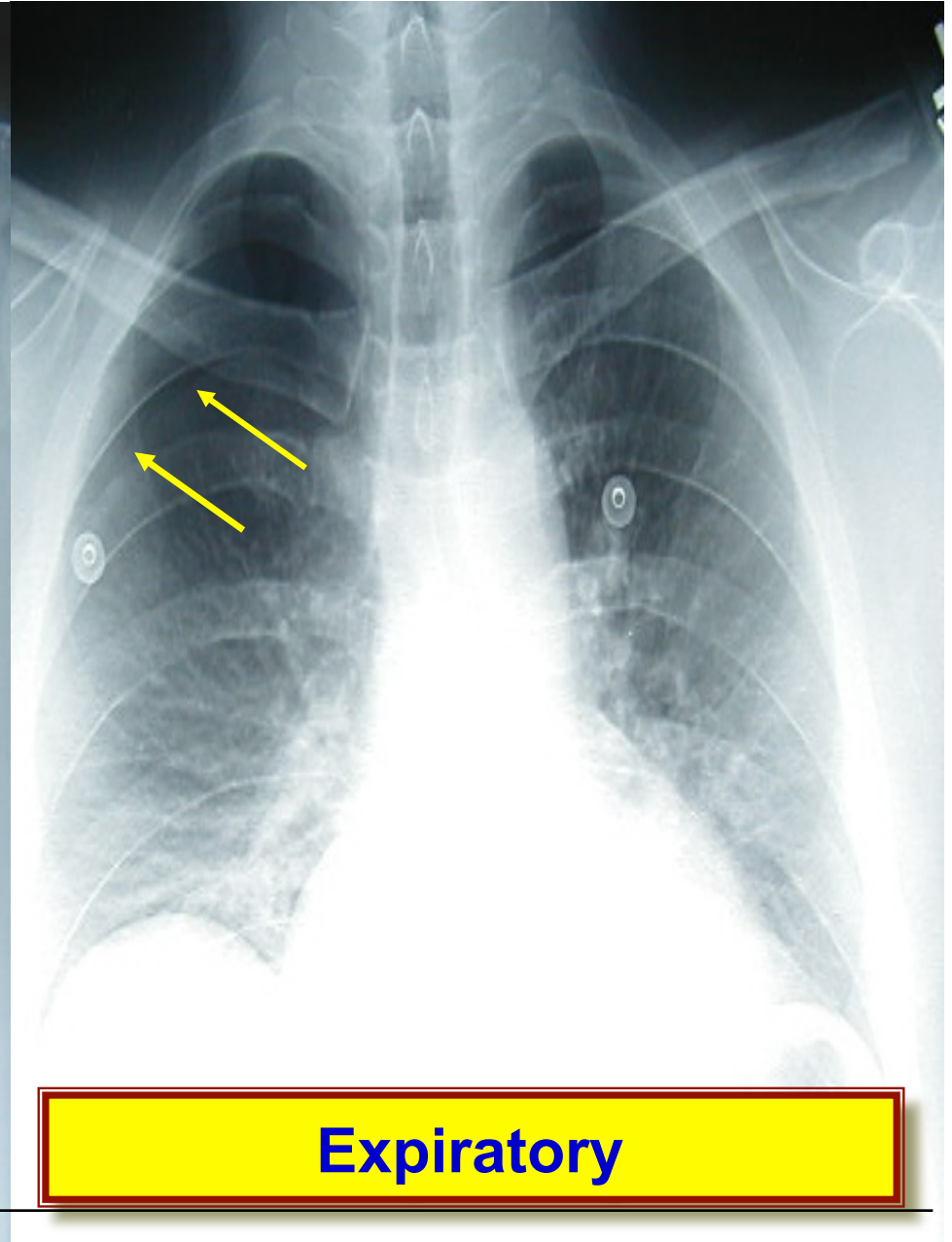
No vessels past line

Density equal
to other lung

Pneumothorax



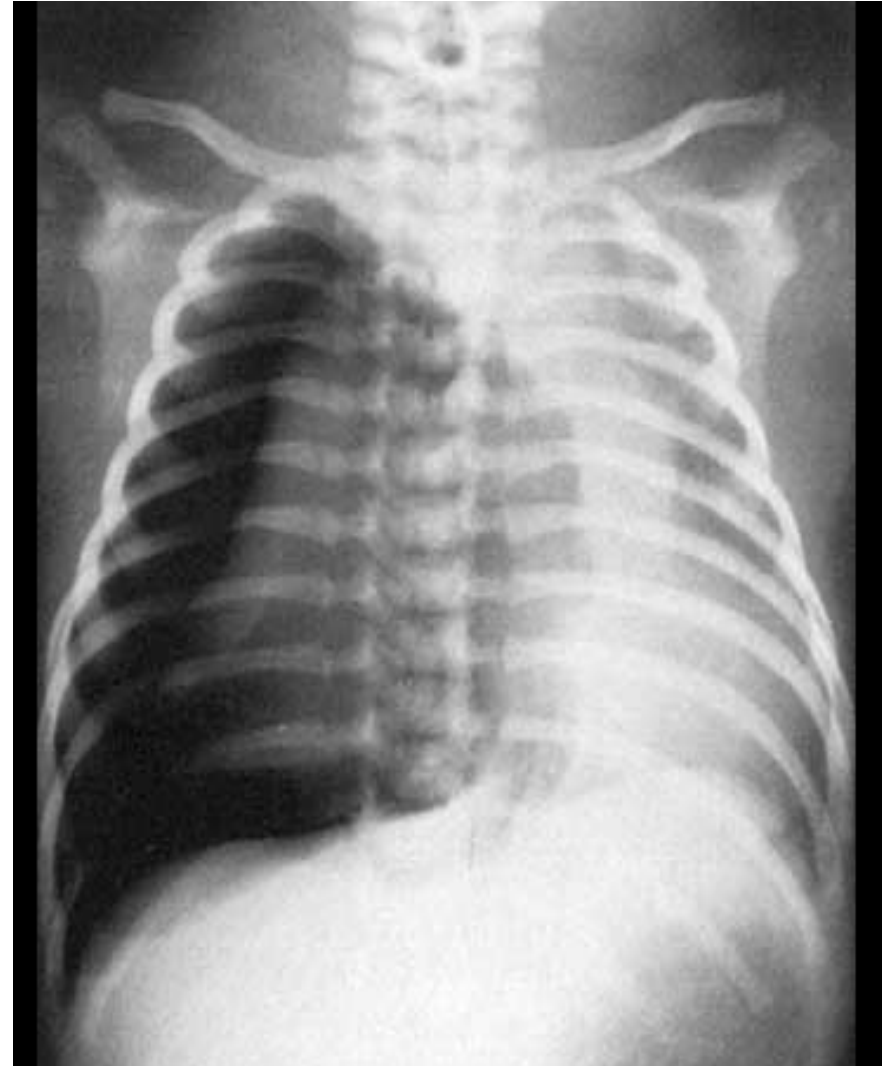
Inspiratory



Expiratory

Tension Pneumothorax

- **Pathophysiology**
 - Pleural defect creates one-way valve, leading to positive pressure in pleural space
 - Mediastinal shift → pressure on SVC → hypotension → arrest
- **Diagnosis**
 - Clinical - do not wait for CXR
- **Treatment**
 - Needle thoracostomy in 2nd ICS at MCL
 - Follow up with chest tube



Hemoptysis

- **Causes**

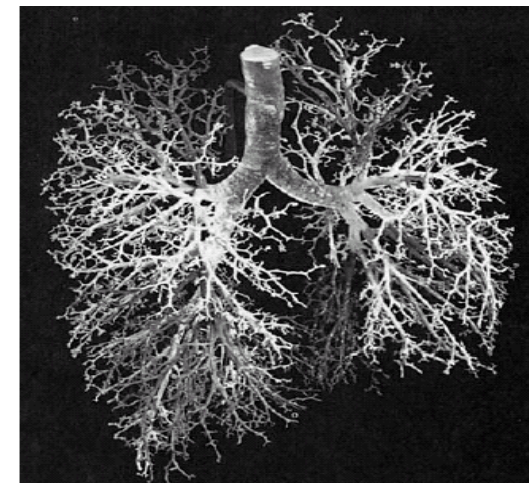
- ***Most common is acute bronchitis***
- Other infections
 - pneumonia, bronchiectasis
- Neoplastic
- TB
- Vasculitis
- Mycetoma (fungal balls)
- Cardiovascular



Sputum is bright, red, frothy and alkaline compared with hematemesis

- **Minor versus Massive**

- Massive: >600mL in 24 hrs or 50mL in single cough
- Death by asphyxiation not hemorrhage



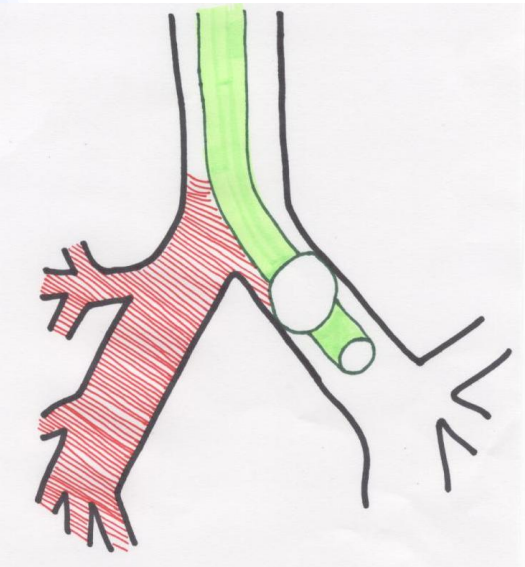
Bronchopulmonary tree

Massive Hemoptysis

Treatment

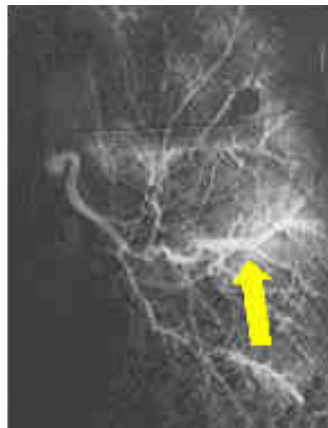


Keep the bleeding side down



Selective mainstem intubation

- A**
 - Supplemental O₂
 - Rapid sequence intubation
 - Large bore ETT (>7.5)
- B**
 - Keep the bleeding side down
 - Aggressive pulmonary toilet
 - Selective mainstem intubation
- C**
 - Correct coagulopathy
 - Fluid and/or blood resuscitation



Bronchial artery embolization will often be required.

Open surgery may also be necessary.

Pneumomediastinum

- Often benign

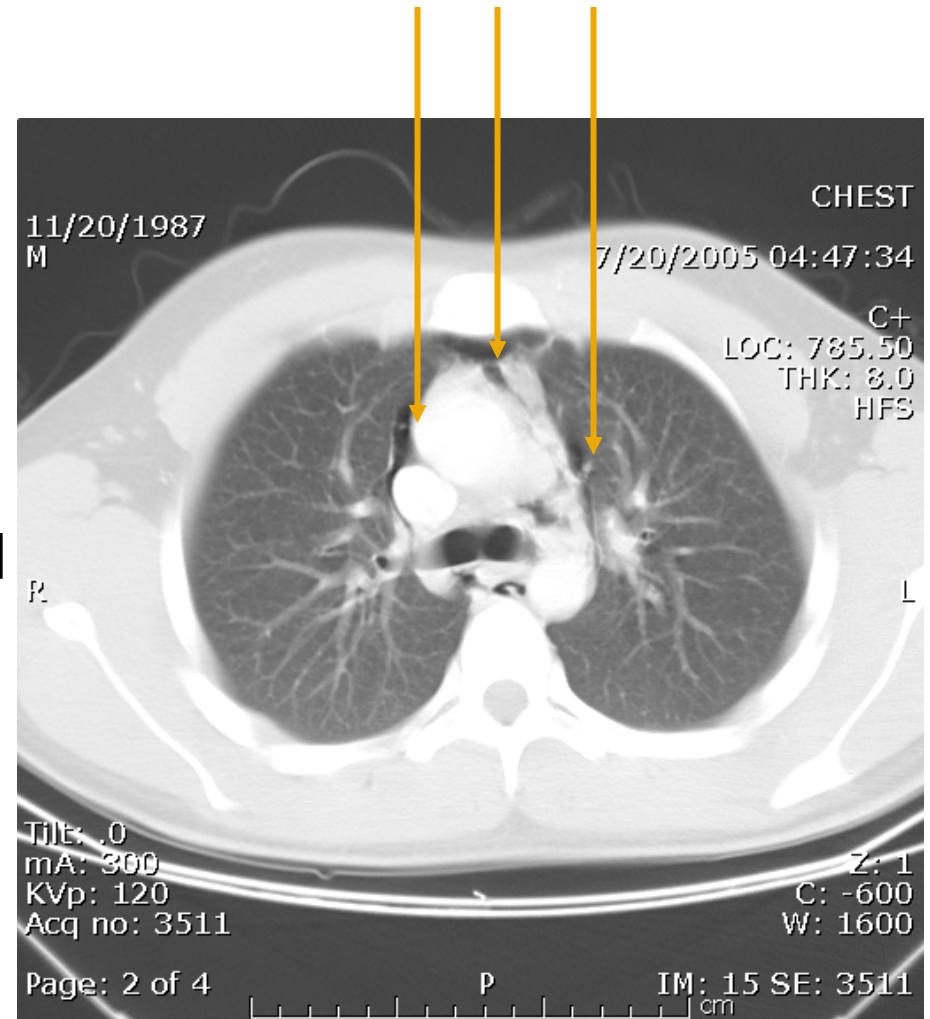
In Trauma

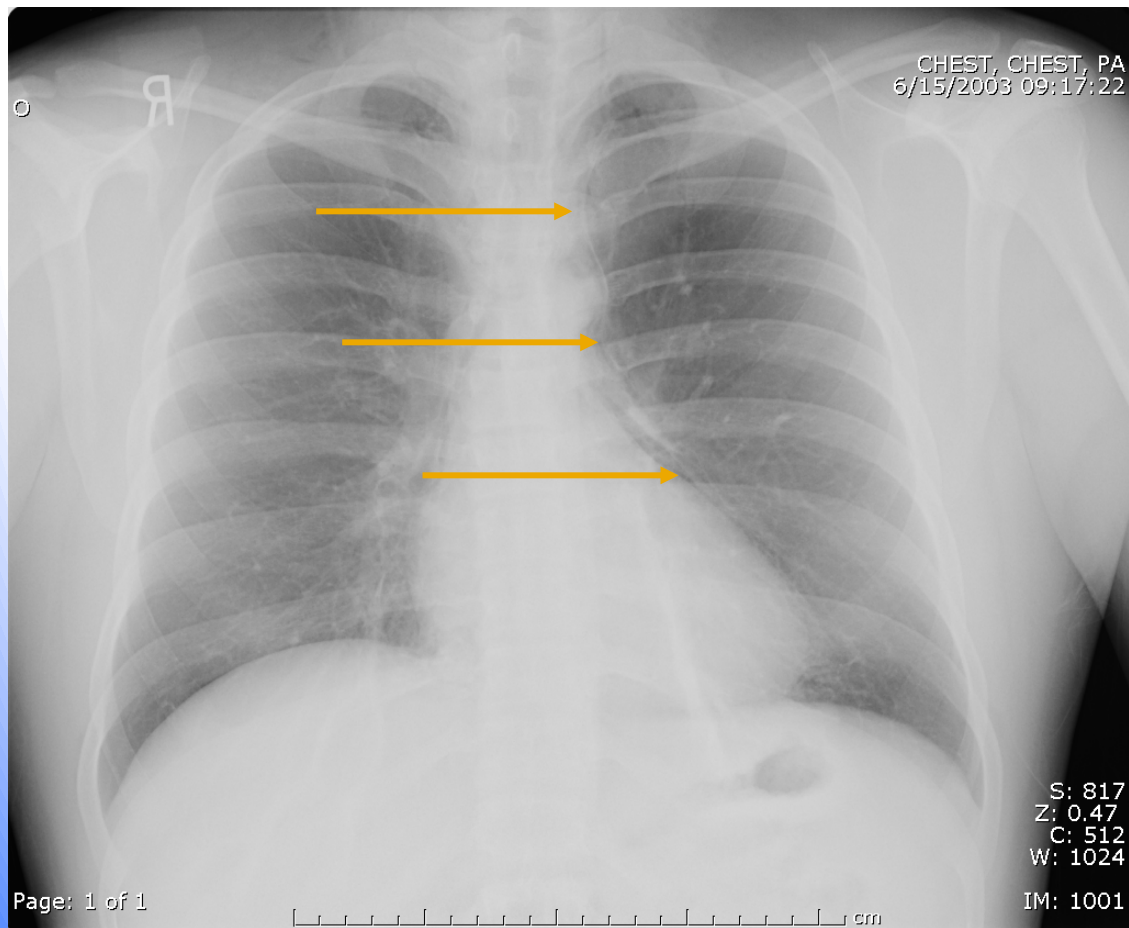
Consider *tracheobronchial injury*

In Non-trauma

Consider *Boerhaave's syndrome*

- Hamman's crunch (sound heard synchronous with heart beat)
- Tension pneumomediastinum
 - Rare
 - Presents as hypotension
 - Sternal notch blunt dissection to relieve tension





Stripe of air on CXR



Mediastinal air on lateral neck film

Pleural Effusion

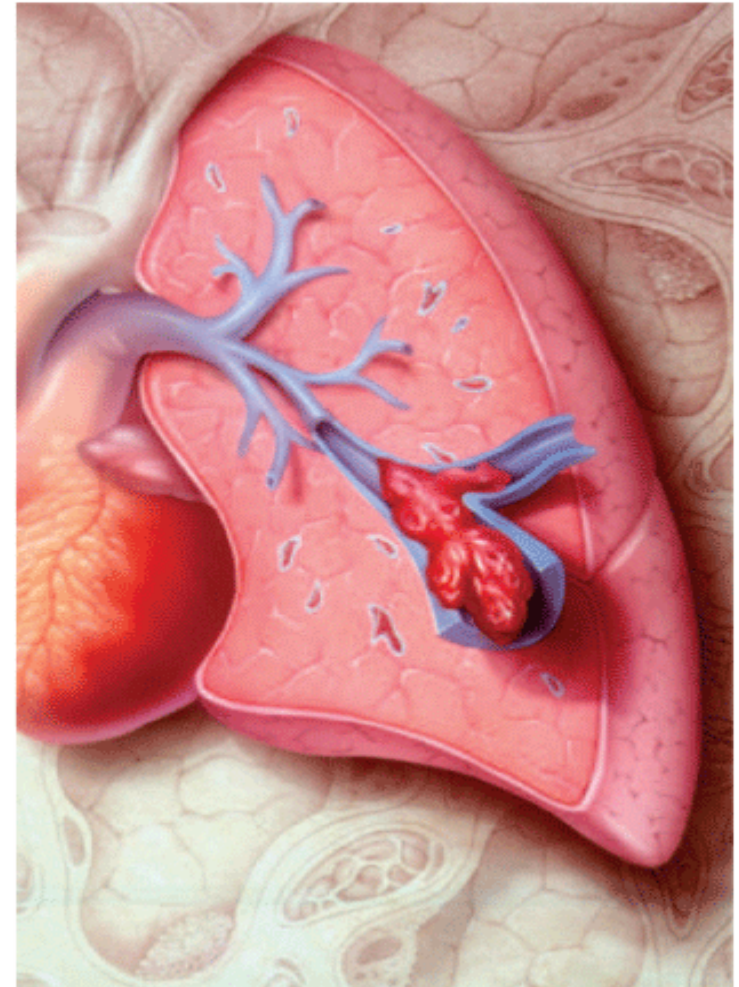
Transudative vs. Exudative

	Transudate	Exudate
Pathophysiology	↑ hydrostatic pressure or ↓ oncotic pressure	Neoplastic Inflammatory Infectious
Common Causes	CHF Cirrhosis Nephrotic syndrome	Lung cancer Lupus (SLE), RA Pneumonia, TB, abscess
Pleural Fluid Analysis	Total protein <3 mg/dL Pleural/serum protein <0.5 LDH <200 IU/mL	Total protein >3 mg/dL Pleural/serum protein >0.5 LDH >200 IU/mL
Management	Directed at underlying cause May need further work-up (exudates) Therapeutic thoracentesis or tube if resp. distress	

Pulmonary Embolus (1)

Risks

- **Virchow's triad**
 - **Stasis**
 - Immobilization, catheters
 - CHF, COPD
 - **Endothelial damage**
 - Trauma, postoperative
 - Smoking
 - **Hypercoagulable states**
 - Cancer
 - Hormonal (pregnancy, OCP, estrogen therapy)
 - SLE (lupus anticoagulant)
 - HIV, nephrotic syndrome (antithrombin III deficiency)

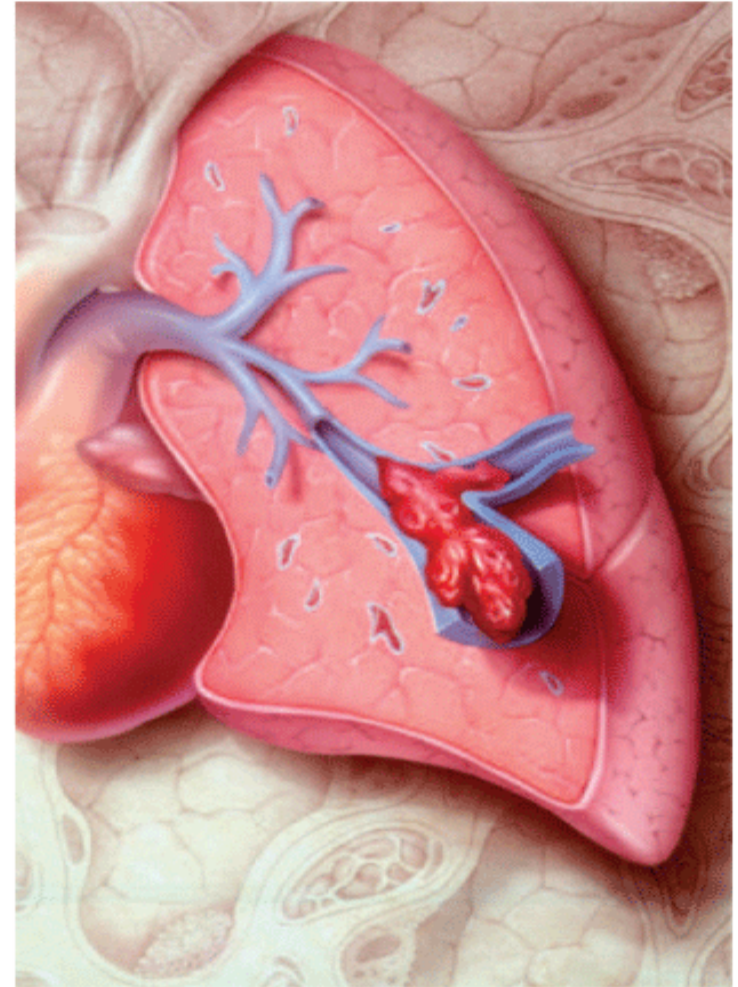


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Pulmonary Embolus (2)

Clinical Presentation

- **Symptoms**
 - Dyspnea
 - Pleuritic chest pain
 - Syncope
- **Signs**
 - Tachypnea
 - Tachycardia
 - DVT
 - Wheezing or rales
 - Fever (pulmonary infarction)
 - Shock



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Pulmonary Embolus (3)

Diagnosis – The Role of Pretest Probability

Well's Criteria for PE

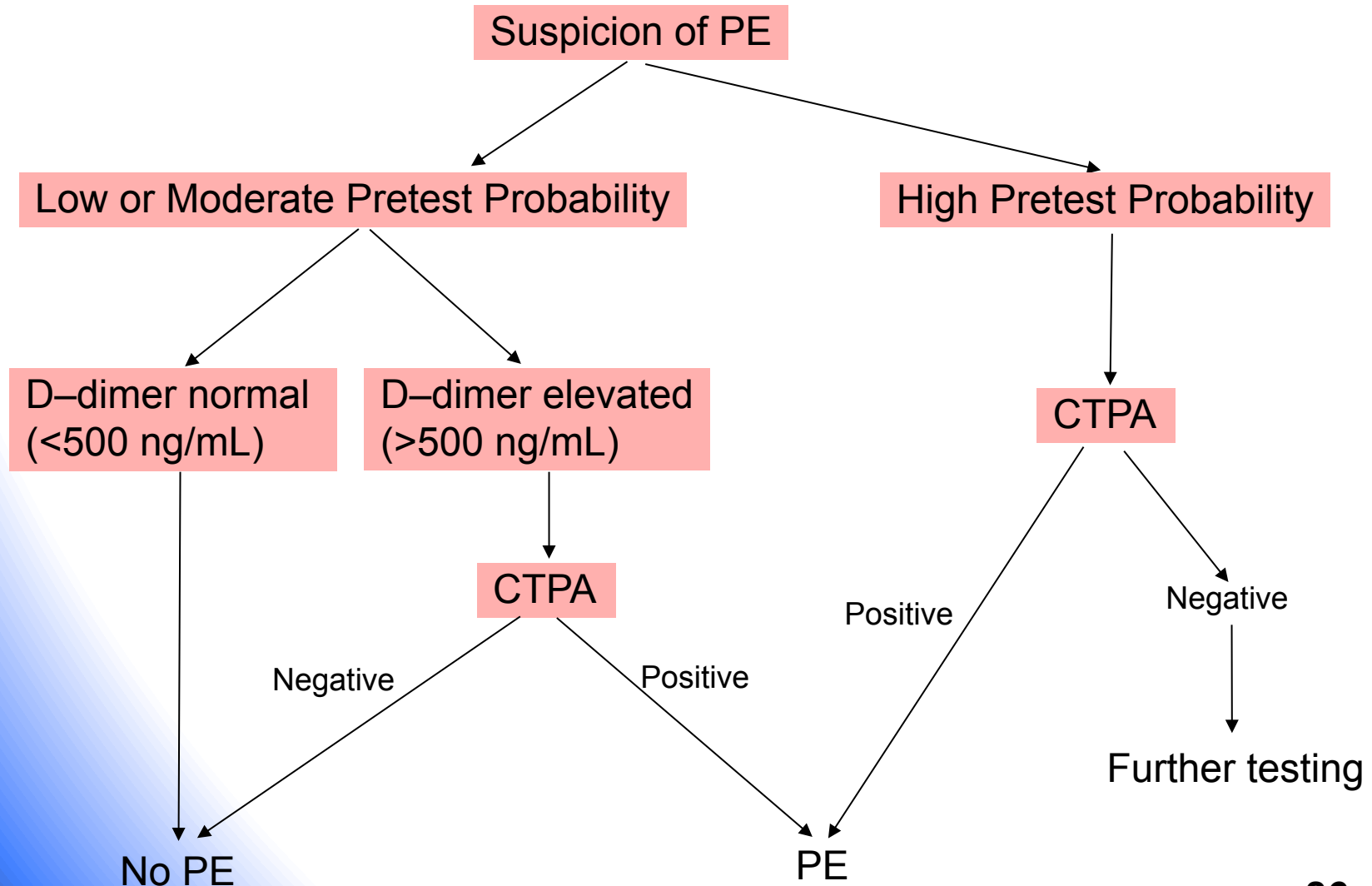
Clinical Signs and Symptoms of DVT?	Yes +3
PE Is #1 Diagnosis, or Equally Likely	Yes +3
Heart Rate > 100?	Yes +1.5
Immobilization at least 3 days, or Surgery in the Previous 4 weeks	Yes +1.5
Previous, objectively diagnosed PE or DVT?	Yes +1.5
Hemoptysis?	Yes +1
Malignancy w/ Rx within 6 mo, or palliative?	Yes +1

SCORE

- **Diagnostic workup involves Bayesian approach**
 - *Definition:* incorporation of *pre-test probability* to guide aggressiveness of workup
- **Pretest probability can be:**
 - estimated by MD
 - or –
 - calculated using a scoring system (e.g. Wells criteria)

Pulmonary Embolus (4)

Diagnosis – Sample Algorithm



Pulmonary Embolus (5)

Diagnosis – Basic Tests

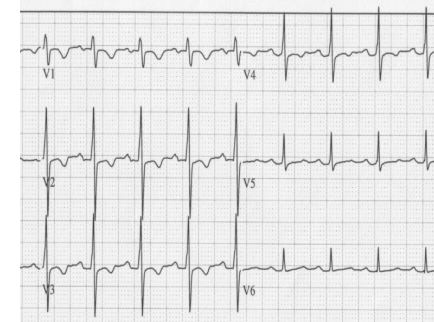
ABG

- Most commonly abnormal but non-specific
- Hypoxemia, \uparrow A-a gradient
- As A-a gradient \uparrow , PE more likely (but up to 25% have $P_aO_2 > 80$)



EKG

- Most commonly abnormal but non-specific
 - e.g. non-specific ST/T changes
- May see signs of acute right heart strain:
 - Inverted T waves V1-V4
 - S1Q3T3
 - RBBB
 - P pulmonale
 - Right axis deviation
 - Tachycardia



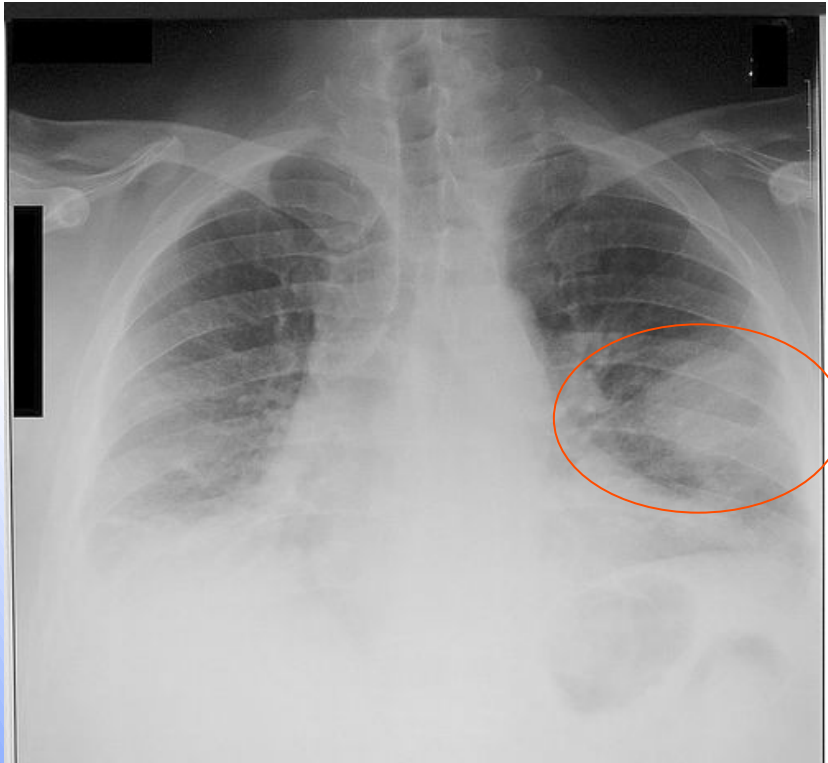
CXR

- Most commonly abnormal but non-specific
 - e.g. elevated hemidiaphragm
- Less common but *more specific* signs:
 - Hampton's hump (pleural based wedge infarction)
 - Westermark's sign (oligemia distal to infarct)



Pulmonary Embolus (6)

Radiologic Signs of a Large PE



Hampton's Hump

Wedge-shaped pulmonary infarction broadest at the pleural edge



Westermark Sign

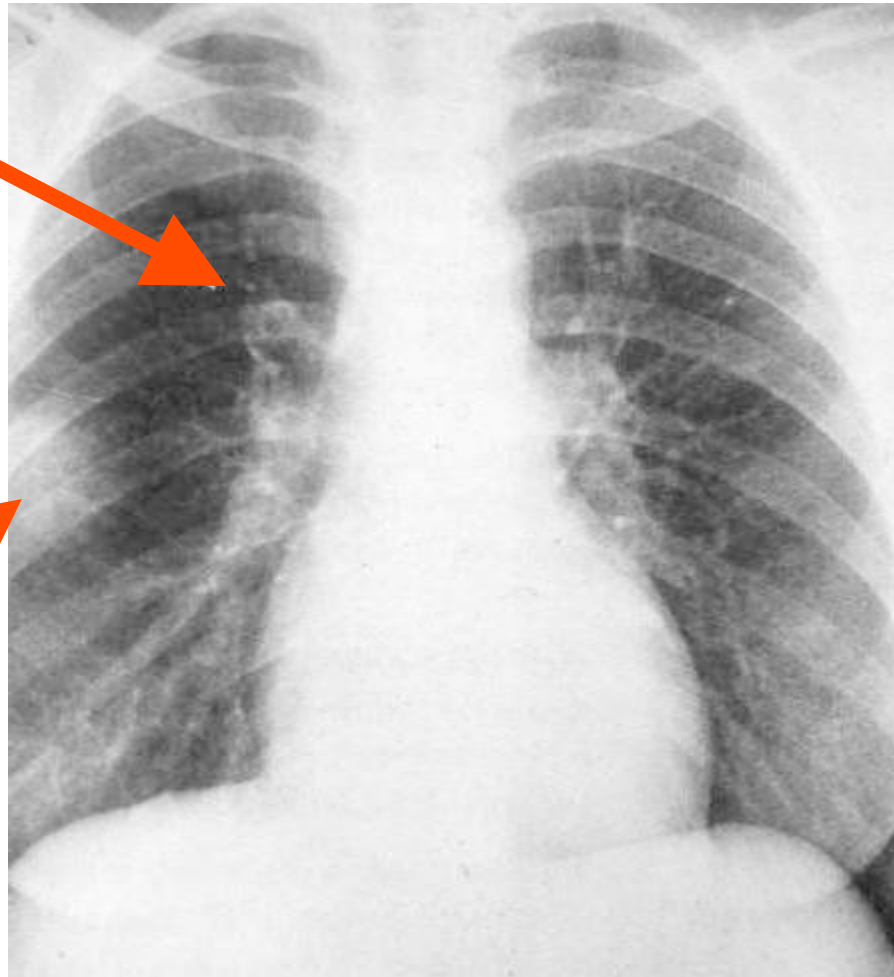
Marked decrease vascularity distal to a large PE

Pulmonary Embolus (7)

Radiologic Signs of a Large PE

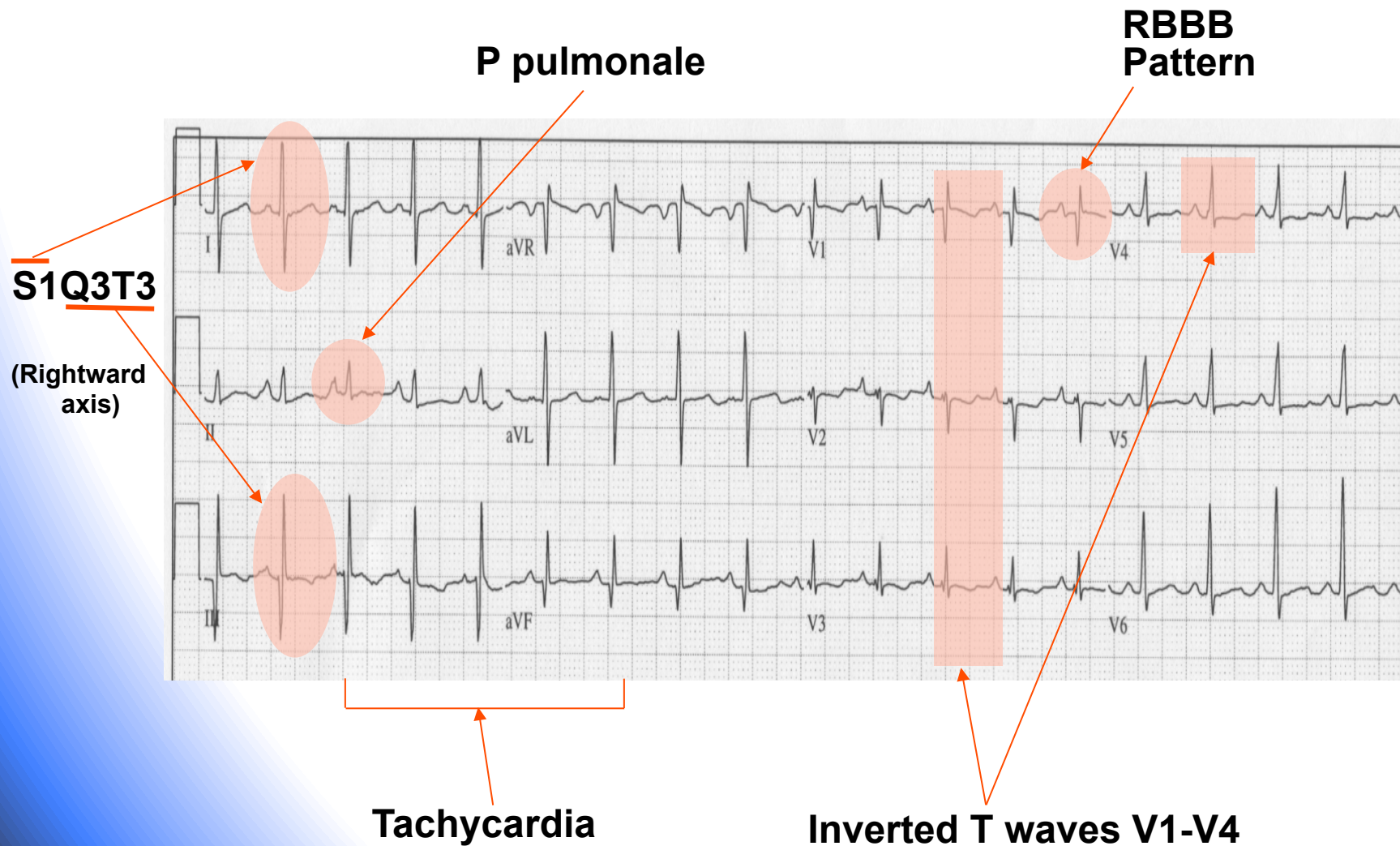
Westermark sign
(oligemia distal to PE)

Hampton's hump
(pleural based wedge infarction)



Pulmonary Embolus (8)

EKG Findings of right heart strain



Pulmonary Embolus (9)

Diagnosis – Basic Tests

D dimer

Type of assay matters

- ELISA superior to latex agglutination
- Quantitative superior to qualitative

Sensitive but not sensitive enough

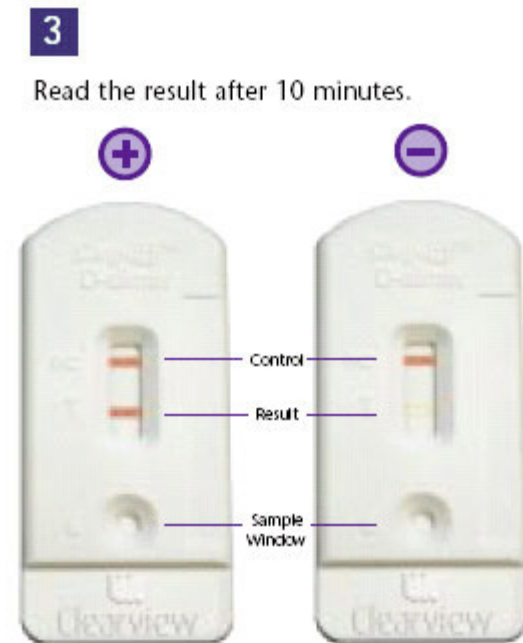
- Must still proceed with imaging on high-risk patients

Not specific

- Must proceed with imaging even when positive

CAUSES OF FALSE POSITIVE D-DIMER TEST

Trauma	Stroke/MI
Pregnancy	Infection
Recent surgery	New indwelling catheter
Inflammatory disease (e.g. SLE)	



A Bedside Qualitative D-dimer test

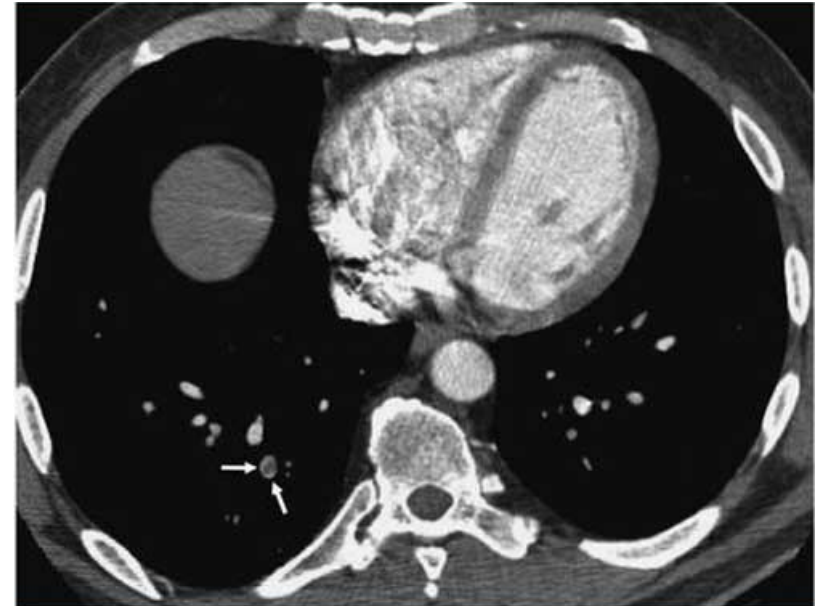
Pulmonary Embolus (10)

Diagnosis – Imaging

CTPA

Offers specific alternative diagnoses

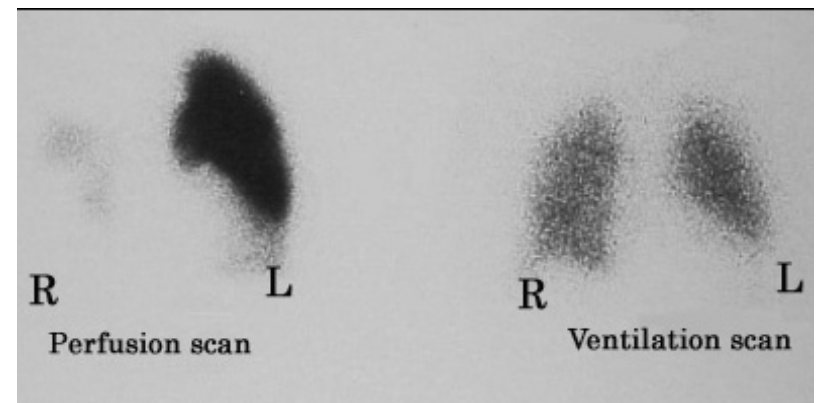
When negative, not sufficiently sensitive to rule out PE in high risk patients



Filling defect on CTPA

VQ Scanning

When negative (normal), sufficiently sensitive to rule out PE in high risk patients



Large VQ mismatch on VQ scan

Pulmonary Embolus (11)

Treatment

- **Heparin**
 - Sufficient doses are important
 - 80u/kg bolus, followed by 18u/hour infusion
 - May use enoxaparin 1mg/kg q12hours
- **IVC Filter (Greenfield)**
 - Can be used when anticoagulation is contraindicated
- **Fibrinolytics (tPA)**
 - Now indicated only for PE causing shock
 - Echocardiogram showing RV enlargement may help identify candidates
- **Surgical embolectomy**
 - Rarely indicated but may be life saving
 - Involves using bypass (and hence heparin)

THE 7 P's OF RSI

P Preparation

P Preoxygenation

P Pretreatment

P Paralysis With Induction

P Protection And Positioning

P Placement And Proof

P Post-intubation Management

t – 10 minutes

TIME ZERO

t + 90 seconds

The Difficult Airway (1)

- ***Predicting a crisis in RSI***

- ***Always ask:***

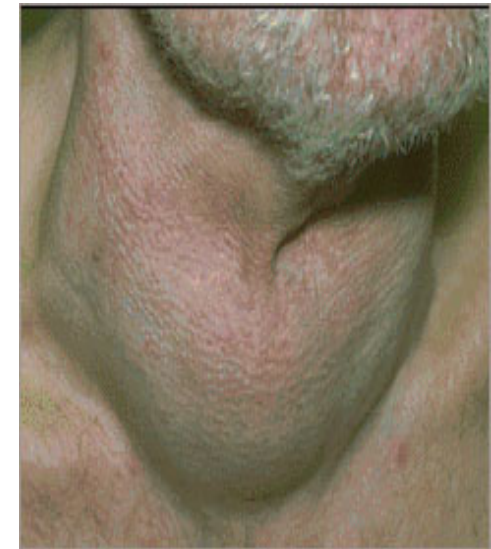
- ***CAN I BAG*** THIS PATIENT
 - ***CAN I TUBE*** THIS PATIENT
 - ***CAN I CRIC*** THIS PATIENT



Hard to Bag (BVM)



Hard to Tube (ETT)



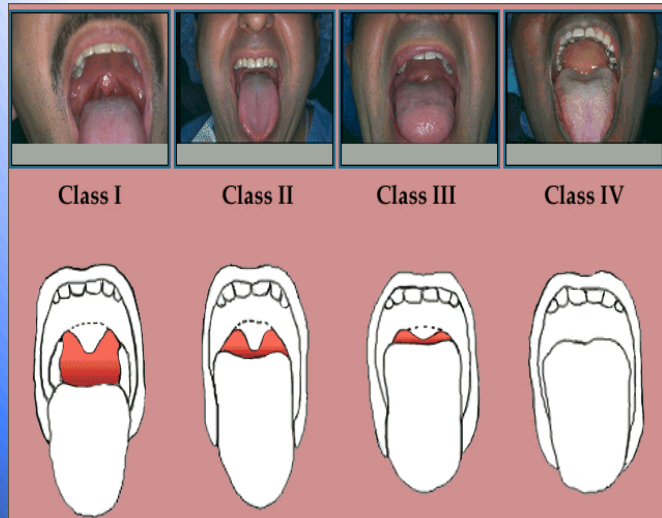
Hard to Cric

The Difficult Airway (2)

CAN I TUBE THIS PATIENT?

The 3-3-2 Rule

- Mouth opening = 3 fingers
- Hyoid-chin distance = 3 fingers
- Thyroid cartilage-mouth floor distance = 2 fingers



Mallampati score

Look at general anatomy
Evaluate the 3-3-2 rule
Mallampati score
Obststruction
Neck mobility



Patients who fail the 3-3-2 Rule

The Difficult Airway (3)

Scenarios

- ***Anterior airway***
 - Attempt using adjunct
 - Adjuncts: gum elastic bougie, lighted stylet, intubating laryngeal mask airway (LMA)
- ***Angioedema***
 - Swelling is anterior
 - Attempt awake nasopharyngeal intubation
- ***Penetrating neck trauma***
 - Paralysis may cause *airway collapse*
 - Attempt awake intubation
 - Consider ketamine for sedation



Tracheostomies

Approach to Respiratory Distress

ASSUME AIRWAY OBSTRUCTION FIRST

1

Remove inner cannula
Suction
Irrigate with saline

if patient not better

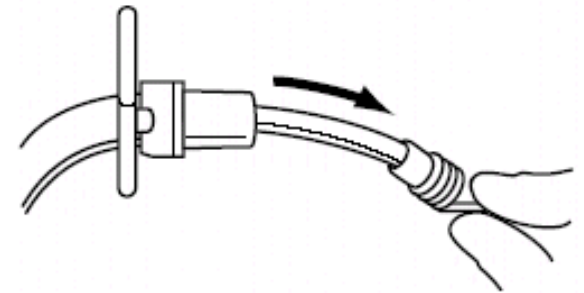
2

Remove (+/- replace) entire tracheostomy
(over a catheter if there is a concern of losing site)

if patient not better

3

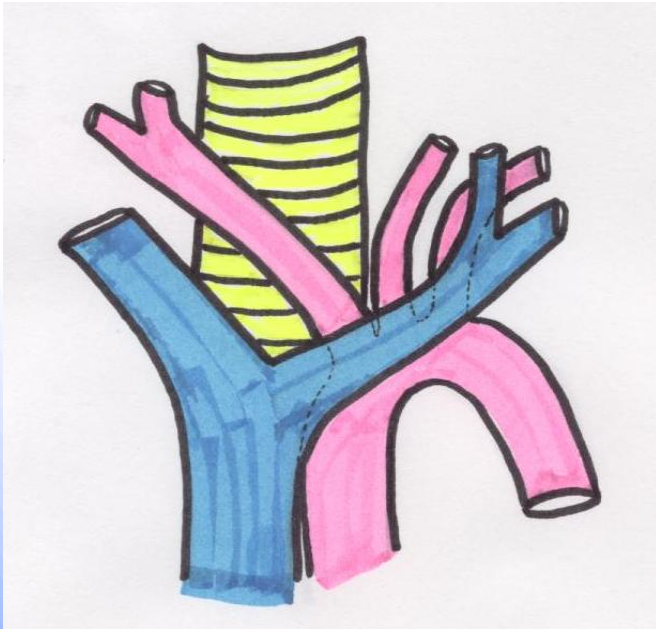
Find another cause for the respiratory distress



Removing inner cannula

Tracheostomy Bleeding

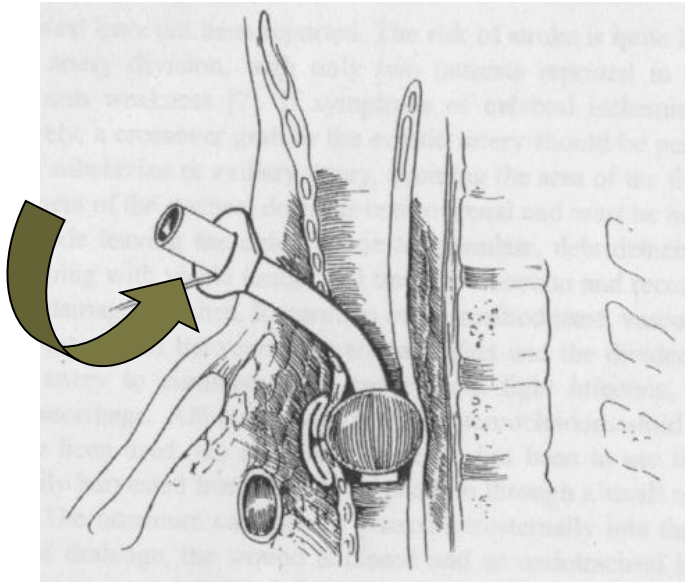
Tracheoinnominate Fistula



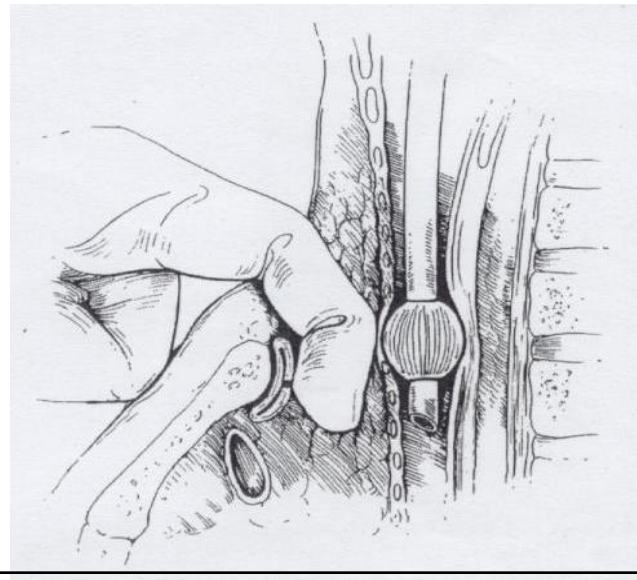
The innominate artery lies adjacent to the tracheostomy site.

With new or ill-fitting tubes, life-threatening bleeding may ensue.

Any significant bleeding must be taken seriously.



In cases of life-threatening bleeding, hyperinflation of the balloon and levering of the tracheal tube may be attempted.



A desperation maneuver.

Patient is intubated from above and a finger is inserted through the trachea hole for direct pressure on the artery.

PULMONARY QUESTIONS

A 75 year old smoker presents with pleuritic chest pain and shortness of breath. He just returned from an 8 hour car trip. Which of the following is the most appropriate next step?

- A. ABG
- B. D-dimer
- C. Lower extremity venography
- D. CT Pulmonary angiogram
- E. Ventilation scan

A patient presents with a sudden onset of SOB. Last menses: Current. PMHx: Endometriosis. Breath sounds are diminished, on the right. HR: 123; RR: 28; BP: 84/50; Pox: 88%. What should you do?

- A. Request a pulmonary consult
- B. Do a needle decompression
- C. Do a stat CT scan of the chest
- D. Initiate thrombolytic therapy
- E. Order a D-dimer

A 65 y/o male presents with a COPD Exacerbation. His ECG reveals a SVT at 130 bpm. The PR intervals are variable and the P-wave morphologies are variable. He is hemodynamically stable. What is the most effective treatment for this dysrhythmia?

- A. 0.5 mg Digoxin IVP
- B. Lopressor 5 –10 mg slow IVP
- C. Esmolol
- D. Verapamil 2.5 mg IVP
- E. Initiate supplemental oxygenation and nebulized albuterol

A 64 y/o patient presents with a 3 day history of productive cough, fever and chills. He has a history of COPD and DM. He was given Azithromycin 500 mg PO at his Dr's office. What additional antibiotic would be most appropriate?

- A. Ampicillin
- B. Gentamicin
- C. Clindamycin
- D. Vancomycin
- E. Ceftriaxone

An AIDS patient presents with a cough and fever. His CD4 count is 100. BP: 102/55; RR: 24; HR: 110; POx: 91%. CXR = bilateral interstitial infiltrates, what is the most appropriate treatment?

- A. Bactrim
- B. Zithromax
- C. Bactrim and steroids
- D. Pentamidine
- E. Ceftriaxone and Gentamicin

Characteristics of PCP pneumonia in AIDS patients include which of the following features?

- A. Maculopapular rash
- B. Normal blood gases
- C. Increased LDH
- D. Classic RUL infiltrate with bulging fissure
- E. CD4 > 200

A 78 y/o female presents with a cough for 4 hours after a choking episode at the nursing home. L.S.: mild wheezing and scattered rhonchi. Her chest radiograph is normal. POx: 85% on RA. The most appropriate statement is:

- A. The patient's presentation is consistent with PE
- B. The patient has an aspiration pneumonia
- C. The patient can be discharged, as her x-ray is normal
- D. Antibiotics are indicated immediately
- E. The patient should have a PEG tube placed

A 45 y/o male presents in January with a cough, rust colored sputum, pleuritic chest pain, fever and rigors. Which statement is true?

- A. The etiologic agent is the most common for community acquired pneumonia
- B. Excellent prognosis despite non-treatment
- C. This presentation is most consistent with *Legionella pneumophila*
- D. GS = PMNs and Gram negative diplococci
- E. Meningitis is not associated with this pathogen

A 35 y/o HIV positive patient with a CD4 count of 600 has a cough, night sweats and weight loss. His PPD converted 12 months ago. Which CXR finding is most consistent with his diagnosis?

- A. Diffuse interstitial changes
- B. Left pleural effusion
- C. Left upper lobe/apical opacity with cavitation
- D. Right lower lobe opacity with hilar adenopathy
- E. Reticulonodular pattern

A 52 y/o patient presents with fever and a cough productive of “currant jelly” sputum. The patient has a history of alcoholism. Regarding the most likely etiology, which of the following is true?

- A. More common in alcoholics and diabetics
- B. Can be treated as an outpatient
- C. Is not associated with empyema
- D. Organism = Gram positive rod
- E. Is only community acquired

Regarding pulmonary embolism, which of the following statements is correct?

- A. A negative doppler ultrasound of the lower extremities excludes the diagnosis
- B. Lower extremity DVT is not considered a major cause of pulmonary emboli
- C. A negative CT cannot rule out segmental or sub-segmental PE
- D. Lower extremity ultrasound is the study of choice in pregnancy
- E. A normal ABG excludes PE

Which of these findings is typical for the diagnosis of legionella pneumonia in a 70 year old man?

- A. GI symptoms
- B. Hyponatremia
- C. During the Winter
- D. Pathogen seen on sputum Gram stain
- E. A well-appearing patient

A 6-month-old presents with significant new-onset wheezing in association with fever and rhinorrhea. CXR = Hyperinflation. Which of the following is true?

- A. The likely cause is respiratory syncytial virus
- B. Steroid therapy is an essential component of care
- C. Chest x-rays are usually very abnormal
- D. Antiviral therapy is routinely indicated
- E. Albuterol is never beneficial

Treatment for Anthrax would include any of the following except...?

- A. Penicillin
- B. Levofloxacin
- C. Pentamidine
- D. Doxycycline
- E. Ciprofloxacin

Which of the following most appropriately describes Psittacosis?

- A. Seen primarily in the southwestern United States
- B. Hilar adenopathy is typical on the chest radiograph
- C. Associated with hepatitis
- D. Also known as *Coxiella burnetii*
- E. Associated with bird handlers

A 21 y/o asthmatic presents in severe respiratory distress. The patient is intubated. Which of the following is true, regarding permissive hypercapnea?

- A. It is intended to reduce barotrauma
- B. Respiratory acidosis is not tolerated well by mechanically ventilated patients
- C. Achieved by reducing the expiratory time of the ventilatory cycle
- D. Rapid normalization of the PCO_2 is critical
- E. Pulse oximeter readings should remain 100%

Which type of patient is more likely to demonstrate cyanosis?

- A. A patient with sickle cell anemia
- B. A patient with COPD
- C. A patient with chronic renal failure
- D. A pregnant patient
- E. A patient with CO poisoning

A 3 y/o presents with an acute onset of coughing. He has mild bronchospasm unresponsive to albuterol. He has no URI symptoms. CXR = Hyperinflation on the right side and volume loss on the left. Which of the following is the most likely cause of his cough?

- A. The patient has a foreign body on the left
- B. The patient has laryngotracheobronchitis
- C. The patient has an atypical pneumonia
- D. The patient has a left sided pneumothorax
- E. The patient has a foreign body on the right

A 78 y/o patient presents with a new pleural effusion. A diagnostic and therapeutic thoracentesis is performed. Which of the following is consistent with an exudative effusion?

- A. Total protein < 3 g/dl
- B. Pleural protein/Serum protein < 0.5
- C. WBC < 100/hpf
- D. LDH > 200 IU/ml
- E. Pleural glucose > 100 mg/dl

The superior vena cava syndrome is most often:

- A. a manifestation of non-Hodgkin's lymphoma in the chest
- B. associated with ptosis and anhidrosis on the affected side
- C. associated with increased intracranial pressure
- D. a result of hypertensive crises
- E. a self-limiting disease process

Pulmonary Answer Key

- | | |
|-------|-------|
| 1. D | 11. C |
| 2. B | 12. A |
| 3. E | 13. A |
| 4. E | 14. C |
| 5. C | 15. E |
| 6. C | 16. A |
| 7. B | 17. B |
| 8. A | 18. E |
| 9. C | 19. D |
| 10. A | 20. C |