Interpretation of Blood Gases

thick arrows → primary d/o
thin arrows → compensation

Disorder	pH	PCO2	HCO3	Compensation	
Metabolic acidosis	↓	↓	↓	pCO2↓= 1.3 x HCO3↓	→ $HCO_3^{\ominus}$ ↓ = drop in $HCO_3^{\ominus}$ from normal 25
Metabolic alkalosis	↑	↑	↑	pCO2↑= .6 x HCO3↑	
Respiratory acidosis					
a) Acute	↓	↑	↑	HCO3↑= .1 x pCO2↑	$pH = 7.40 - [0.008 \times (PCO_2 - 40)]$
b) Chronic	↓	↑	↑	HCO3↑= .4 x pCO2↑	$pH = 7.40 - [0.003 \times (PCO_2 - 40)]$
Respiratory alkalosis					
a) Acute	↑	↓	↓	HCO3↓= .2 x pCO2↓	$pH = 7.40 + [0.008 \times (40 - PCO_2)]$
b) Chronic	↑	↓	↓	HCO3↓= .5 x pCO2↓	$pH = 7.40 + [0.003 \times (40 - PCO_2)]$
M + R Acidosis	↓	↑	↓	← PCO_2 + $HCO_3^{\ominus}$ move in opposite directions	
M + R Alkalosis	↑	↓	↑		

$pCO_2 = [(1.5 \times (HCO_3) + 8) \pm 2]$
$pCO_2 = [(0.7 \times (HCO_3) + 21) \pm 2]$

(Normal Values: pH: 7.40-7.44 pCO2: 40 mm Hg HCO3: 25-28 mEq/L)

Interpreting Acid-Base disorders

1. Determine pH status (< 7.40...Acidemia, > 7.44...Alkalemia)
2. Primary process is respiratory or metabolic or both
   - Alkalemia: Respiratory if PCO2 < 40, metabolic if HCO3 > 28
     Respiratory + Metabolic if PCO2 < 40 + HCO3 > 28
   - Acidemia: Respiratory if PCO2 > 44, Metabolic if HCO3 < 25
     Respiratory + Metabolic if PCO2 > 44 + HCO3 < 25
3. Calculate the serum anion gap (nl: 3-10 mEq/L)
   - Anion gap= Sodium- (bicarbonate+ chloride)
4. Check the degree of compensation
5. Is there is 1:1 relationship between anions in blood
   - a) In high anion gap metabolic acidosis, every 1-point increase in anion gap should be accompanied by a 1-mEq/L drop in HCO3
   - b) In normal anion gap metabolic acidosis every 1-mEq/L increase in chloride should be accompanied by a 1-mEq/L drop in HCO3

→ to look for a 3rd d/o
Metabolic Acidosis + Alkalosis can coexist

AGapExcess : $HCO_3^{\ominus}$ Deficit
(Abap - 12) : (24 - $HCO_3^{\ominus}$)
↓ non Abg acidosis (ratio <1)
↓ metabolic alkalosis (ratio >1)

Causes of Respiratory Acidosis

1. Drug overdose
2. Cerebrovascular accident
3. Asthma
4. COPD
5. Obesity
6. Sleep Apnea

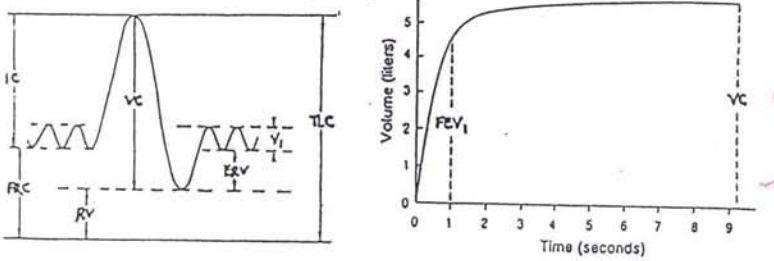
Causes Of Respiratory Alkalosis

1. Sepsis
2. Pulmonary embolism
3. Pregnancy (compensated)
4. Anxiety and pain
5. Hypoxia
6. Salicylate intoxication

High Altitude Pulm. Edema
Tx: Move to lower altitude
(Lasix + Nifedipine)
or Acetazolamide x2 days prior to arrival

Pulmonary Function Testing

Spirographic Tracing **Spirometric Volume-Time curve**



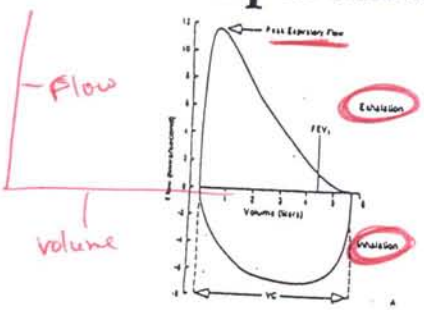
Normally:
$FEV_1 : FVC$ > 0.70
< 0.70 → obstruction
after bronchodilation:
↑ 12% → reversible dis.

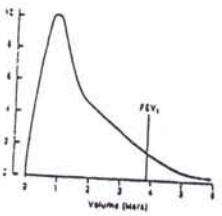
TLC=Total lung capacity, VC= Vital Capacity, Vt= Tidal volume
FRC= Functional residual capacity, RV= Residual Volume
IC= Inspiratory capacity, ERV= expiratory reserve volume
FEV1= Forced expiratory volume in 1s
$FEF_{25-75\%}$= Average expiratory flow rate during the middle 50% of VC (MMFR)

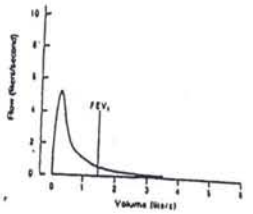
Peak Flows:
vs personal best
- < 20% ↓ - normal
- 20-50% ↓ - mod obst.
- > 50% ↓ - Severe obst.

Meth acholine Challenge
↓ FEV_1 by > 20%
↓
(+) test

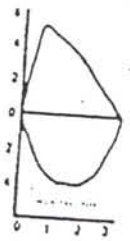
Spirometric Flow-Volume curves

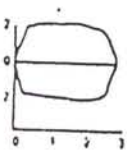


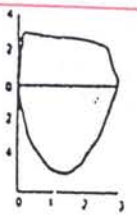




Normal **Mild Obstruction** **Severe Obstruction**



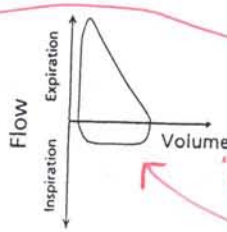




Restrictive
↓ volumes w/ curve looks normal

Fixed Extrathoracic Obstruction
Ex.) Tracheal Stenosis

Large Intrathoracic Obstruction
- flattening only w/ expiration
Ex.) Intra bronchial Ca.



"cut-off" inspiratory flow

Variable extrathoracic Obstruction

Throat tightness
voice Δ's
Inspiratory difficulty

- flattening w/ inspiration only
Ex.) vocal cord paralysis → vocal cords midly adduct during inspiration

Tx: Speech Tx
Relaxation Techniques

Dx: Flow-volume loops

Pulmonary Function Tests

causes of ↓DLCO: -Diffuse alveolar hemorrhage (DAH)

Pattern	FVC	FEV1/FVC	TLC	RV	DLCO	MIP (Max Insp. Pressure)	MEP (Max Exp. Pressure)
Obstructive	↓	↓	N/↑	↑	N/↓ (80% to Normal)	N	N
Restrictive:							
① Parenchymal	↓	N	↓	↓	↓	N	N → ILD
② Neuro-muscular (Inspiratory)	↓	N	↓	N/↓	N	↓	N
③ Neuro-muscular (Ins. + exp)	↓	N	↓	↑	N	↓	↓
Chest wall stiffness	↓	N	↓	variable	N	N	N

Ex) Kyphoscoliosis, Obesity

DLCO is reduced in diseases involving the lung parenchyma

Ex) 70 y.o. woman w/ exertional dyspnea +h/o heavy smoking w/ achronic cough
PO_2 - 64
↓
✓ PFT's to look for COPD

Ex) 52 y.o. smoker w/ exertional dyspnea + ⑤ rales
PFT's: FVC - 60%, FEV_1 - 55%, FEV_1/FVC - 80%, RV - 60%, DLCO - 40%
Dx: Restrictive Dis. (Likely ILD)

Respiratory Diseases

Obstructive (normal DLCO / ↓DLCO): Asthma, COPD, Bronchiectasis, Cystic fibrosis

Restrictive (Parenchymal): Sarcoidosis, Pulmonary fibrosis, Pneumoconiosis, Interstitial lung disease caused by drugs or radiation

Restrictive (Neuro-muscular): Gullain-Barre syndrome, Myasthenia gravis, Muscular dystrophies, Diaphragmatic weakness

→ Indications for Intubation
VC < 20 ml/kg
Max Insp. Pressure < 30
Max Exp. Pressure < 40

Restrictive (Chest wall stiffness): Kyphoscoliosis, Ankylosing spondylitis, Obesity

← may need cough assist maneuvers/ te

Evaluation of Hypoxia

- pCO_2 ↑ (Hypoventilation) A-a gradient
  - Normal → Pure hypoventilation
  - Increased → Hypoventilation + Other mechanisms
- PCO_2 N → A-a gradient $= [150 - (1.25 \times PaCO_2)] - PaO_2$
  - Increased → ↓ Ins. O_2 → O2 Therapy
    - pO2 corrected → V/Q Mismatching
    - pO2 not corrected → Shunting
  - Normal

↑'d shunting when pt's w/ pneumonia lie on side of the pneumonia

A-a gradient = PAO2 - PaO2 → Normal < 15
PAO2 = 150 - 1.25 x PaCO2
Q 10 yrs. ↑ by 3

Pleural effusion ↑ pushes trachea away from affected side
Trachea shifted Towards Lesions
white-out ↑ Collapsed Lung
① Atelectasis
⑤ Chronic Fibrosis
③ Tension Pneumothorax

Ex) Pt. on the vent, restless + hypotensive w/ ↓ BS's on ® side w/ tracheal deviation to the (L).
↑ pressure alarm on vent
- peaks now 60
- plateaus now 58
Dx: Tension Pneumothorax
Tx: Decompression w/ large bore IV thru 2nd interspace

Improve Survival
- Stop smoking
- O_2 Tx

Consequences OF Chronic Hypoxia In COPD

1. Reduces exercise performance
2. Secondary erythrocytosis
3. Pulmonary artery hypertension and cor pulmonale
4. Impairs CNS function

Restrictive Lung Diz.
FVC <80%

Indications for Long-term Oxygen Therapy in COPD

O_2 Tx Goals:
① PO_2 60-65
② SO_2 90-92

-overcorrection can cause CO_2 retention → resp. failure

1. $PaO_2 \leq 55$ mm Hg or $SaO_2 \leq 88$ %
2. PaO_2 56-59 mm Hg or $SaO_2 \leq 89$ % in the presence of any of the following
   a) Edema b) P pulmonale on EKG C) Hematocrit ≥ 56 %
3. Nocturnal $SaO_2 \leq 88$ + complications attributed to hypoxia
4. Exercise $PaO_2 \leq 55$ or $SaO_2 \leq 88$ %
5. In-flight O2 if resting $PaO_2 \leq 72$

Ex.) Smoker w/ DOE
Hyperresonant on exam
↓ improvement w/ bronchodilators on PFT's
FEV_1/FVC - 60%
FEV_1 - 36%
✓ exercise PO_2 + SO_2
↓
if ↓ then O_2 tx

-if already on home O_2 then by 1 L for flights

flight can induce a fall in PO_2 of 25-30
use regression equations to calculate PO_2's @ altitude

Goal: keep PO_2 > 50

Stages of COPD

Based on FEV1

Stage		FEV1/FVC	FEV1
0	At risk	Normal	Normal
1	Mild	< 70%	≥ 80%
II	Moderate	< 70%	50-79%
III	Severe	< 70%	30-49%
IV	Very Severe	< 70%	< 30% or < 50% with respiratory failure

Post-Bronchodilator Response FEV_1

Ex.) 50 yo. m/ recurrent cough + yellow sputum w/ recurrent hemoptysis too. Had pneumonia 10 yrs. ago
coarse crackles @ the (R) base
CXR → prominent cystic spaces (R) LL plus streaky opacities in orientation of bronchial tree
↓
"tramtrack lines"

Dx: Bronchiectasis
↓
confirm Dx w/ HRCT

Treatment of COPD

Step 1: Short acting inhaled broncodilator for acute relief of symptoms (Albuterol or Ipratropium)
Step 2: Long acting inhaled broncodilator (Formoterol, salmetrol or tiotropium)
Step 3: Combination of anticholinergic and B-agonist broncodilator
Step 4: Theophyllin or combination of inhaled corticosteroid and long acting B-agonist
Step 5: Pulmonary rehabilitation, treatment of hypoxia, lung-volume-reduction surgery

Does not improve survival

Indicated w/ FEV_1 <50% + recurrent exacerbations

poor candidacy — ↓ DL_{CO}, ↓ FEV_1, Homogeneous Emphysema

Treatment Of Acute Exacerbation Of COPD

Ex.) 36 yo. smoker w/ emphysema + (B) bullae bullae
✓ α-1 anti-trypsin levels
↓
-cirrhosis
-HCC
-abnormal LFT's

Stage I + II → outpatient tx
Stages > III → admit
IV pt's → Tx stage like CAP → cover Gram⊖'s too

1. **O2:** Target O2 saturation 90-92% and PO2 60-65
2. **Broncodilators:** Ipratropium + albuterol
3. **Antibiotics:** 10 day course of narrow spectrum antibiotic (TMP/SMX, doxycycline or amoxicillin) → most common organism (HIB)
4. **Steroids PO/IV for 8-10 days**
5. **Non invasive ventilation**

Theophyllin Clearance

limited bronchodilation - mediastinum → Hepatic

Therapeutic Range - (8-12)

Decreases	Increases
1. CHF	1. Smoking
2. Liver disease	2. Marijuana
3. Hypoxia	3. Phenobarbital
4. Old age	4. Phenytoin
5. Fever	5. Rifampin
6. Ciprofloxacin	6. Alcohol
7. Erythromycin	
8. Cimetidine	
9. Allopurinol	
10. Propranolol	

Side Effects
- Tremor
- Palp's
- N/V
- seizures
- dysrhythmias → death

Methemoglobinemia
- Causes: (1) Benzocaine Spray (Local Anesthetic)
(2) Dapsone
(3) Nitrites
Tx: IV Methylene Blue
Ex.) 26 y.o. w/ dyspnea that began 2 hrs. ago after receiving a dental filling 8 hrs. ago. Now w/ peripheral cyanosis
PO_2 - 86 · arterial blood is brown
Sats - ↓
Dx:

Dx: - sweat-chloride test

CF
- AR inheritance
- Causes:
CFTR gene mutation
↓
leads to bronchiectasis & obstructive lung dis
- ↑'d risk of recurrent endobronchial infec.
- most common organism: Pseudomonas (Staph, HIB)
- manifestations:
- pancreatic insuf.
- DM
- obstructive biliary dis.
- azoospermia
- Prophylaxis (Infec):
- inhaled Tobra or Azithro PO
- mucolytics
- nebulized recombinant DNA-ase
- nebulized NAC

Causes of Diffuse Bronchiectasis

- prior pneumonia too

1. **Hypogammaglobulinemia**
2. **Selective deficiency of IGG 2, 3 or 4**
3. **Dyskinetic celia syndrome** → -bronchiectasis -sinusitis -infertility in males if (A) situs inversus → Kartegener's
Dx: via Bx of nasopharynx testes or bronchi
4. **Cystic fibrosis**

Causes OF Cough

Acute (< 3 weeks)

Common cold
Bacterial sinusitis (Abx x 10 days)
Exacerbation of chronic bronchitis
Allergic rhinitis
Bordetella pertussis infection. (post-tussive emesis)
Tx: Azithro or Bactrim

Subacute (3-8 weeks)

Post infection
Subacute sinusitis (Abx x 3 wks)
Asthma
B. pertussis infection

Chronic Cough (> 8 weeks)

Cough asthma Dx: Trial of Albuterol
Postnasal- drip
Ace inhibitors
Gastroesophageal reflux
Chronic bronchitis
Eosinophilic bronchitis
- eo's in sputum
- respond to steroids

Vasomotor Rhinitis
- Ipratropium nasal spray

- heartburn
- nocturnal asthma
Tx: PPI's

Cough Asthma
- spirometry → ↓ obstruction
- Best Test → methacholine challenge
- Tx: Inhaled steroids + Albuterol

Signs of Severe Asthma

1. Paradoxical pulse > 12 mm
2. HR > 120 or RR >30
3. Use of accessory muscles
4. Diaphoresis
5. Inability to lie supine
6. Severe dyspnea
7. PO2 <60 mm or PCO2 >40 mm or O2 sat < 90%
8. FEV1orPEFR <30% of predicted or personal best
9. Failure of PEFR to improve at least 10% after initial treatment

Treatment of Asthma

Step 1 : Inhaled beta- agonist PRN
Step 2 : Inhaled beta- agonist PRN +
Anti-inflammatory therapy
- Inhaled steroids -preferred
- Cromolyn or nedocromil
- Leukotriene inhibitors

Step 3 : Add theophyllin or ipratropium bromide or salmeterol
Step 4 : Systemic steroids

Monoclonal IGE Antibody
-skin testing (+) + IgE >30 IU

Management of Asthma

	Intermittent Asthma	Persistent Asthma		
	Mild Intermittent	Mild Persistent	Moderate Persistent	Severe Persistent
Symptoms Day	≤2/week	> 2/week	Daily	Continual
Night	≤2/month	>2/month	> 1/week	Frequent
Treatment	PRN inhaled Short acting beta agonist	Low-dose Inhaled steroid + PRN beta agonist	Low-to medium-dose inhaled steroid + long-acting beta agonist (salmetrol or formoterol)	High-dose inhaled steroid + Long-acting beta agonist + Systemic steroids

Mechanical Ventilation

1. Assist-control ventilation (most common)
2. Intermittent mandatory ventilation (IMV)
3. Pressure- support ventilation
4. Non Invasive Ventilation

Setting of Ventilator

1. Tidal volume : 5-10 ml/ Kg (ARDS 6 ml/kg)
2. Rate:11-14 breaths/ minute (4 breaths < patient spontaneous rate)
3. Minute ventilation: adjusted to achieve a plateau pressure of no > 35 cm of H2O
4. FiO2 : Lowest to achieve PaO2 of 60 mm Hg or an O2 saturation of 90% to avoid O2 toxicity
5. Inspiratory Flow : 60 liters/minute (most patients) COPD patients 100 liters/ minute
6. Trigger senstivity : -1 to -2 cm of H2O
7. PEEP : 5-10 cm of H2O, if required

Exercise-Induced Asthma (shortacting)
Tx: Inhaled β-2 agonist pre-exercise
or Leukotriene Inhibs
or Long-acting β-2 agonist
NPV ~100%
sensitivity 85-95%
Dx: methacholine Challenge Test
Nebs methacholine given then spirometry until ↓20% ↓FEV1 vs. baseline
↓
provocative concentration (PC20)
PC20 <4 mg/mL → Asthma
4-16 → Bronchial Hyperactivity
>16 → Normal
Started pt. requires more 2x Q wk prn meds
or nocturnal s/s more than 2x Q Month

CXR → hyperinflated if ↓ lung volumes
↓
Think extrathoracic obstruction

- FEV1 ↑ by 20% w/ bronchodilators
↓
(+) bronchodilator response

-useful in atopic asthma
-exercise-induced asthma
- efficacy in intrinsic asthma or COPD is not well-established
-side effect:
-Churg-strauss (vasculitis)

Long-Acting β-Agonists
-Black box warning
-use w/out steroids is not recommended (as monotx)
-↑'d asthmatic deaths

Ex.) Asthma pt. using Albuterol daily + nocturnal symptoms twice weekly
↓
Dx: Moderate Persistent Asthma
↓
Tx: Long-acting β-agonist plus inhaled steroids plus Albuterol prn

Churg-Strauss
-severe asthma despite max tx
-pulmonary eosinophilia
pulmonary infiltrates
(+) P-ANCA
↑CRP/ESL
-sometimes a side effect of leukotriene inhibs.

Ex.) Low pressure Alarm on vent + hypoxemia
↓
Endotracheal tube cuff leak
↓
Tx: Change Tube

-pt. receives preset volume + rate breaths
-spontaneous breathing is allowed
-used as tapering method
-Tv only fixed for vent breaths
-his own breaths get his own Tv's

combines:
A) end-exp. pressure w/
B) insp. pressure
if A + B are same → CPAP
otherwise BIPAP

Reactive Airway Dysfunction Syndrome (RADS):
-asthma-like symptoms following exposure to a single accidental inhalation of irritant

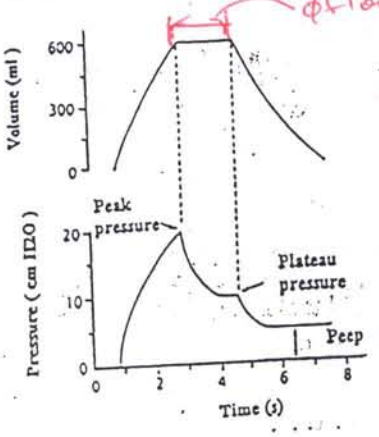
Best weaning method
-SBT/CVT QDay
-Extubate if tolerating 30 mins. of spontaneous breathing
-also D/ing to NIPPV is a good weaning issue

Ex.) Pt. w/ COPD intubated → Tx: IVF's (Hypovolemia)
-SBP's - 140 → 100's
End Expiratory Pressure: ϕ → ϕ auto-PEEP

Auto-PEEP
- can: ↓ BP
↑ HR
↓ venous return
↑ IVP

Tx: ↑ Insp. flow
↓ V_E (minute vent)
Iv Bronchodilators + IVF's
-measure @ end-expiration
↓
ϕ flow
pressure should hit ϕ
if stays ⊕ then PEEP present
↓
end expiratory pressures by occluding airway @ end expiration

Simultaneous Plots of Tidal Volume & Airway Pressure



Inspiration

normally tracing should hit ϕ → ϕ PEEP

Peak pressure (Ppk) - Plateau pressure (Pplat) = Good marker of airway resistance
(nl < 10 cm H_2O)

Plateau pressure measures the peak alveolar pressure and should be kept at < 35 cm H_2O by adjusting minute ventilation to prevent alveolar over-distension

Ex.) COPD or vent becomes agitated w/ ↓ BS's over (R) lung
Peak Pressure - 40
Plateaus - 20
Peak-Plateau = 20
↓
Think mucous plugging
↓
Tx: Suctioning

either ok for pulm. edema due to HF but CPAP-10 (CPAP vs. BIPAP)

Non Invasive Ventilation

To Increase Oxygenation:
↑ Exp. Pressure

To ↓ PCO_2:
↑ Insp. Pressure

Contraindications
- acute cardiac ischemia on EKG

Indications
Severe dyspnea, trachypnea (RR>30/minute)
Hypoxia (PaO_2/FIO_2 < 200)
Stable neurological status
Hemodynamically stable without cardiac arrhythmia or ischemia
PCO_2 of <55 mm

Ex.) Pt. w/ ARDS gets intubated
FiO_2 - 60%
Tv - 800
PO_2 - 60
PEEP - 15
1-hr. later pt. is hypotensive/tachycardic + w/ ↓ UOP
↓
↓ PEEP

Indications of Intubation
APACHE > 22
Failure to maintain PaO_2/FIO_2 > 85
Copious tracheal secretions
PCO_2 > 55mm or pH < 7.30 / 7.25
Systolic BP < 70 mm
GCS < 11

avoid as much as possible in COPD
↑'d morbidity + ↑'d mortality

Complication of Mechanical Ventilation

1. Toxic effects of oxygen: occur when oxygen concentration of .6 or > is required for more than 72 hours. PEEP can help lower FIO2
2. Endotracheal tube complications: laryngeal injury, tracheal stenosis, tracheomalacia
3. Barotrauma: pneumothorax, pneumo-mediastinum, subcutaneous emphysema
4. Hyperinflation: ↓ venous return, ↓ cardiac output, ↓ BP, ↑ HR, ↑ respiratory work (Auto Peep)
5. Nosocomial pneumonia: gram-negative, staph., anaerobes
6. Deconditioning of respiratory muscles
7. Stress ulceration & mild to moderate cholestasis

Ex.) Flu-like illness then resp. failure → intubation
CXR → (B) alveolar infiltrates
ϕ improvement w/ Abx
WBC's - normal
Dx: Acute Interstitial Pneumonitis
-survival 15-40% poor prognosis

Ex.) Heroin-Induced Pulm. Edema
Tx: IV Naloxone + O_2

Ex.) 30 y.o. female w/ dry, non-productive cough + dyspnea + low-grade temp
Completed course of Rad Tx for Hodgkin's w/ mediastinal involvement
CXR → patchy alveolar filling densities, ϕ in one lobe, crosses lobe margins (ϕ confined)
↑ ESR/CRP
↑ LDH
Dx: Radiation Pneumonitis

Pleural Effusion

Ex.) 60 y.o. w/ fevers/chills
(L)-sided pleuritic pain x 6 days
CXR → (L) pleural effusion

Plan:
- Prior to Abx → drain w/ tap
↓
(+) Gramstain w/ exudate
↓
Chest tube

Light's Criteria

	Transudate	Exudate
1. PF/serum protein ratio	< .5	> .5
3. PF/serum LDH ratio	< .6	> .6
4. Total LDH	< 2/3 of normal upper limit	> 2/3 of NUL

Only 1 (+) makes exudate

best yield for TB markers + pleural Bx
- adenosine deaminase
- gamma-IFN
- predominance of mesothelial cells on differential

Low Glucose (<60mg/dL or PF/serum glucose < .5)
Bacterial infections, Rheumatoid pleurisy, Malignancy

High Amylase (> 500 units/ml)
Acute and chronic pancreatitis, Esophageal rupture, Malignancy

Cells
> 50% Lymphocytes...TB, Malignancy
> 50% Polymorphonuclear... Acute inflammation
RBC > 100000/ml...Malignancy, Infarction, Trauma

Causes of Pleural Effusion

Transudate	Exudate
1. CHF	1. Neoplastic
2. Nephrosis	2. Infections (pneumonia, TB, Empyema)
3. Cirrhosis	3. PE
4. PE	4. RA, SLE (+ ANA, ↓ complement)
5. Myxedema	5. Pancreatitis
	6. Esophageal perforation (pH < 4.0, ↑ amylase)
	7. Dressler's Syndrome
	8. Intra-abdominal abscess
	9. Chylothorax → Trigs > 110 w/
	10. Pseudochylothorax ↓ chol

usually PE effusions are exudative ~80%

Physical signs
- Dullness
- ↓ BS's
- tactile fremitus ↓

Consolidation Signs
- Dullness
- tactile fremitus ↑
- ↑ bronchial breathsounds

Pneumothorax Sign
- ↓ BS's
- hyperresonant percussion

Parapneumonic Effusions
- typ large effusions which layers more than 10 mm or fever > 72 hrs. or loculated fluid
- Empyema → fluid infected on gross pus, wBc's > 1000, pH < 7.2
Ex.) (+) Gramstain ↓ gluc

Chest tube Indications:
1. Gross Pus
2. (+) Gramstain
3. Gluc < 60
4. pH < 7.2
5. Loculations

Pneumothorax

- injury patients → CT

HIV pt's w/ AIDS + PCP outbreak
↓
↑ risk of tension pneumo

- if post-expansion CXR shows pulm. edema then get CT

Spontaneous: No obvious precipitating factor
Secondary: Complications of preexisting lung disease (COPD, pneumocystis, interstial diseases, lung cancer, thoracic endometriosis)
Iatrogenic: Complication of diagnostic and therapeutic interventions
Traumatic: Penetrating or blunt trauma to the chest

Ex.) 26 y.o. female on OCP's w/ sudden-onset (R)-sided chest pain while running
dyspnea too
↓ BS's w/ hyperresonance
↓
Dx: spontaneous pneumo

Treatment: Observation if < 15%, simple aspiration, chest tube insertion → 70% success rate → 90% success rate
Prevention of Recurrence: Sclerosing agent through chest tube w/ pleurodesis
(VATS) – Video assisted thoracoscopic surgery
Limited thoracotomy

Sleep Apnea Syndrome

↑ HTN, MI, CVA risk

cessation > 10 s

hypopnea → ↓ flow by 50%

	Central	Obstructive	Mixed
Airflow at nose	——	——	——
Chest wall movement	——	ΔΔ	ΔΔ
Snoring	-	(+)	(+)

starts ex central then becomes obstructive

seen more in children

↑'d efforts to overcome obstruction

Suspect Sleep Apnea

Calculate adjusted neck circumference

(+ 4 cm ↑BP), + 3 cm (+ snoring), + 3cm (+ choking or gasping)

- < 43 cm → Day time symptoms
  - None or mild → Consevative Rx
  - Moderate to severe → Polysomnography
- > 43 cm → Polysomnography

Apnea-hypopnea index (AHI)

AHI	< 5	5-30	> 30
Day time symptoms:	Moderate/severe	Mild/none	Moderate/severe
	Check for other causes sleep disturbance	Conservative treatment	Trial of CPAP

If improved w/ position Δ then try that 1st then

Sarcoidosis (ILD)

Systemic granulomatous disease of unknown etiology

Characterized by accumulation of CD4 lymphocytes in tissues and noncaseating granulomas

Clinical Manifestations

Lofgren's syndrome: Hilar adenopathy + ankle arthritis + erythema nodosum → good prognosis

Heerfordt syndrome: Parotid enlargement + fever + uveitis + 7th nerve palsy → Tx: topical corticosteroids

Lungs: Stages...1. Bilateral hilar adenopathy 2. Hilar adenopathy + infiltration 3. Infiltration alone 4. Fibrotic bands, bullae, bronchiectasis

Skin: Lupus pernio, erythema nodosum, macules, papules and plaques

Eye: Anterior and posterior uveitis

CNS: Cranial nerve palsy, headache, ataxia, seizure, pituitary involvement

Abdomen: Hepatosplenomegaly, ↑AST/ALT, ↑ALKPO4, cholestatic hepatitis, portal hypertension, cirrhosis

CVS: Cardiomyopathy, tachyarrythmias, bradyarrhythmias

Musculoskeletal: Bony cysts, arthralgias, myositis, arthritis

Others: Hypercalcemia, hypercalciuria, renal stones

Interstial Lung Diseases

- Sclerodermia (Restrictive PFTs)
- MTx Lung
- Sarcoidosis
- Idiopathic pulmonary fibrosis (IPF)
- Hypersensitive pneumonitis
- Bronchiolitis Obliterans Organizing Pneumonia (BOOP)
- Pulmonary Alveolar Proteinosis
- Pulmonary Langerhan's Cell Histiocytosis

ARDS

Causes:
- Sepsis
- gastric aspiration

1. Ratio of PaO2/FIO2 ≤ 200
2. Bilateral pulmonary infiltrates
3. PCW < 18 mm Hg

Best way to follow tissue oxygenation → mixed venous O_2 sat

Tv - 6 mL/kg (IBW) ✓ + keep plateau pressures ≤30

PEEP to maintain O_2

ϕ role of steroids

Xigris (Activated Protein C)

Relative contraindication → INR 3.0 or Plats ≤ 30,000

Absolute contraindication → active GI Bleed

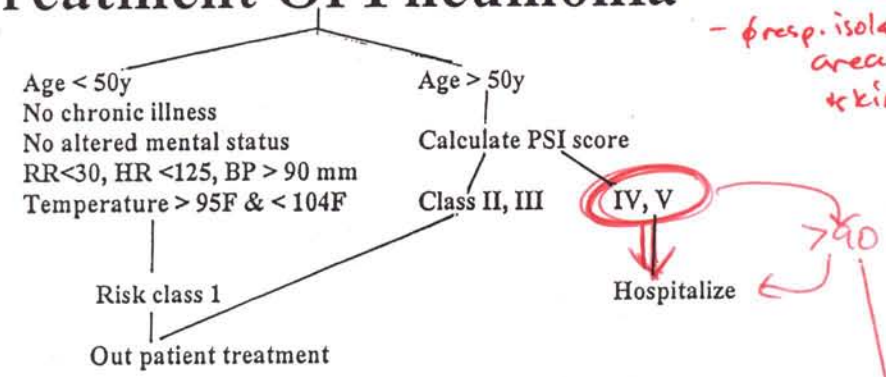
Pneumonia

Community-Acquired	Nosocomial
Strep. pneumoniae	Gram negative bacilli
Mycoplasma	Staph. aureus
Legionella	Anaerobes
Chlamydia, viral	
H. influenzae, staph. aureus	
Moraxella catarrhalis	
Klebsiella	
Tuberculosis	
Pneumocystis carinii	

Sepsis
- correct lactic acidosis + ↑ venous Sat 77% w/in 6 hrs. → ↑ survival

Nerve Agents
Ex.) Sarin Gas
- ACh-esterase inhibs → bronchorrhea, lacrimation, salivation, muscle weakness → paralysis + bronchospasm
- Tx: Pralidoxime
  - (Atropine w/l tx bronchorrhea but ϕ correct muscle weakness / paralysis)
- ϕ resp. isolation needed but areas must be well-vented + skin cleansed

Treatment Of Pneumonia



Ex.) Patient w/ birds @ home
Dyspnea now, fevers/chills
PO_2-60
CXR - Interstitial dis.
PFTs - Restrictive pattern
→ Think Psittacosis
Cause: Chlamydia
Tx: Doxy

Ex.) Pneumonitis w/ cattle/sheep/goats
→ Think Q Fever
Cause: coriella burnetii
- chronic form → endocarditis risk
Tx: Doxy x 14 days (Add Rifampin if present)

Ex.) 30 y.o. female w/ acute-onset severe dyspnea symptoms 1-hr after working in silo
→ Think Silo Filler's Dis.
Cause: Inhalation of nitrous oxide

Pneumonia Severity Index Calculation (PSI score)

Age (years)	(age)
Female	-10
CHF	+10
Neoplastic disease	+30
Liver disease	+20
Cerebrovascular disease	+10
Renal disease	+10
Altered mental status	+20
Nursing home resident	+10
Respiration rate ≥ 30	+20
Systolic BP < 90 mm	+20
Temp < 95F or ≥ 104F	+15
Pulse ≥ 125	+10
Arterial ph < 7.35	+30
BUN ≥ 30 mg/dL	+20
Sodium < 130 meq/L	+20
Glucose ≥ 250 mg/dL	+10
Hct < 30%	+10
PO2 < 60 mm or sat <90%	+10
Pleural effusion	+10

Class II < 70 Class III 71-90 Class IV 91-130 Class V > 130

Mortality: Class I, II, III... <1%, Class IV... 9 %, Class V... 27 %

Outpatient Treatment of Pneumonia

1. No cardiopulmonary disease and no risk factors for DRSP → Drug-resistant Strep pneumo

Oral macrolide (azithromycin or clarithromycin) or doxycycline

2. Cardopulmonary disease and/or risk factors for DRSP infection

Fluoroquinolone with enhanced activity against Strep. pneumoniae
(levofloxacin, gatifloxacin, moxifloxacin)
or
Beta-lactam (cefuroxime, amoxicillin/clavulanic acid, cefpodoxime, amoxicillin)
Plus
Macrolide or doxycycline

Risk Factors for DRSP Infections: → suspected pt's hospitalized >5 days

HCAP → 48 hrs. after admission

1. Age > 65
2. Beta lactam therapy within 3 months
3. Alcoholism
4. Immunosuppression (including steroids)
5. Multiple medical co-morbidities
6. Exposure to a child in day care
7. High DRSP prevalence in the community

Treatment of Pneumonia in Hospitalized Patients

General ward

Respiratory quinolone (levofloxacin, gatifloxacin, moxifloxacin)
or
Beta-lactam + macrolide or doxycycline

Mycoplasma Pneumonia
- CXR out-of-proportion to clinical status

No pseudomonas risk factors: Cefotaxime, ceftriaxone, ampicillin/sulbactum

Pseudomonas risk factors: Cefepime, imipenam, meropenam, piperacillin/tazobactum

Legionella Pneumonia
- assoc. w/ diarrhea + ↑Bun/creat.
- ✓ urinary Ag
Tx: Azithro (IV) x5-10 days

Cyanide Poisoning
- coma
- hypotension
- dysrhythmias
- ↑AGap met. Acidosis
Tx: Sodium IV Thiosulfate

Intensive care unit- no risk factors for Pseudomonas infection

1. Ceftriaxone or cefotaxime + newer quinolone or a macrolide

Intensive care unit-at risk for Pseudomonas infection

Piperacillin-tazobactam or cefepime or imipenam or meropenam
Plus
Ciprofloxacin or high dose levofloxacin
Or
Beta-lactam + aminoglycoside + macrolide or anti-pneumococcal quinolone

Lung Abscess
Tx: Clindamycin and/or Levoquin and/or Flagyl

Risk Factors for Pseudomonas Infections:

1. Bronchiectasis
2. Malnutrition
3. Treatment with > 10 mg of Prednisone/d
4. Previously undiagnosed HIV infection
5. Broad spectrum antibiotic therapy for > 7 days in the past month

Ventilator-Associated Pneumonia
- based on ① resolution of signs & symptoms of infection ② Radiologic improvement ③ d/c vent support needs ④ Improved O2-ation
- no more than 8 days usually required

Risk Factors for Venous Thromboembolism

Age > 50 yrs	Prolonged Immobilization	H/O venous thromboembolism
Cancer	Polycythemia vera	
Obesity	Pregnancy or recent delivery	Major surgery or major trauma
Central venous catheters		Spinal cord injury

Selective estrogen-receptor modulators (tamoxifen, raloxifene)

Estrogens (oral contraceptives, hormone-replacement therapy)

Genetic or acquired thrombophilia

- Factor V Leiden
- Prothrombin G 20210A mutation
- Deficiency of Antithrombin III, protein C, protein S,
- Anticardiolipin antibody syndrome
- Lupus anticoagulant
- Dysfibrogenemia
- Hyperhomocysteinemia
- Elevated levels of factor VIII, IX, XI
- Activated protein C resistance without factor V leiden

Probability of Pulmonary Embolism

Risk Factors:	Points
Clinical signs and symptoms of DVT	3.0
An alternative diagnosis less likely than PE	3.0
HR > 100 beats/minute	1.5
Immobilization or surgery in the previous 4 Wk	1.5
Previous DVT or PE	1.5
Hemoptysis	1.0
Cancer (receiving treatment or treated in the past 6 months)	1.0

Clinical Probability:

Low	<2.0
Moderate	2.0-6.0
High	>6.0

Diagnosis of Pulmonary Embolism

1. D-Dimer
2. Ventilation-Perfusion Lung Scan
3. Spiral CT Angiography
4. Venous Duplex Ultrasonography
5. Pulmonary Angiography

Ventilation Perfusion Lung Scan

Normal: PE ruled out

High probability: PE confirmed

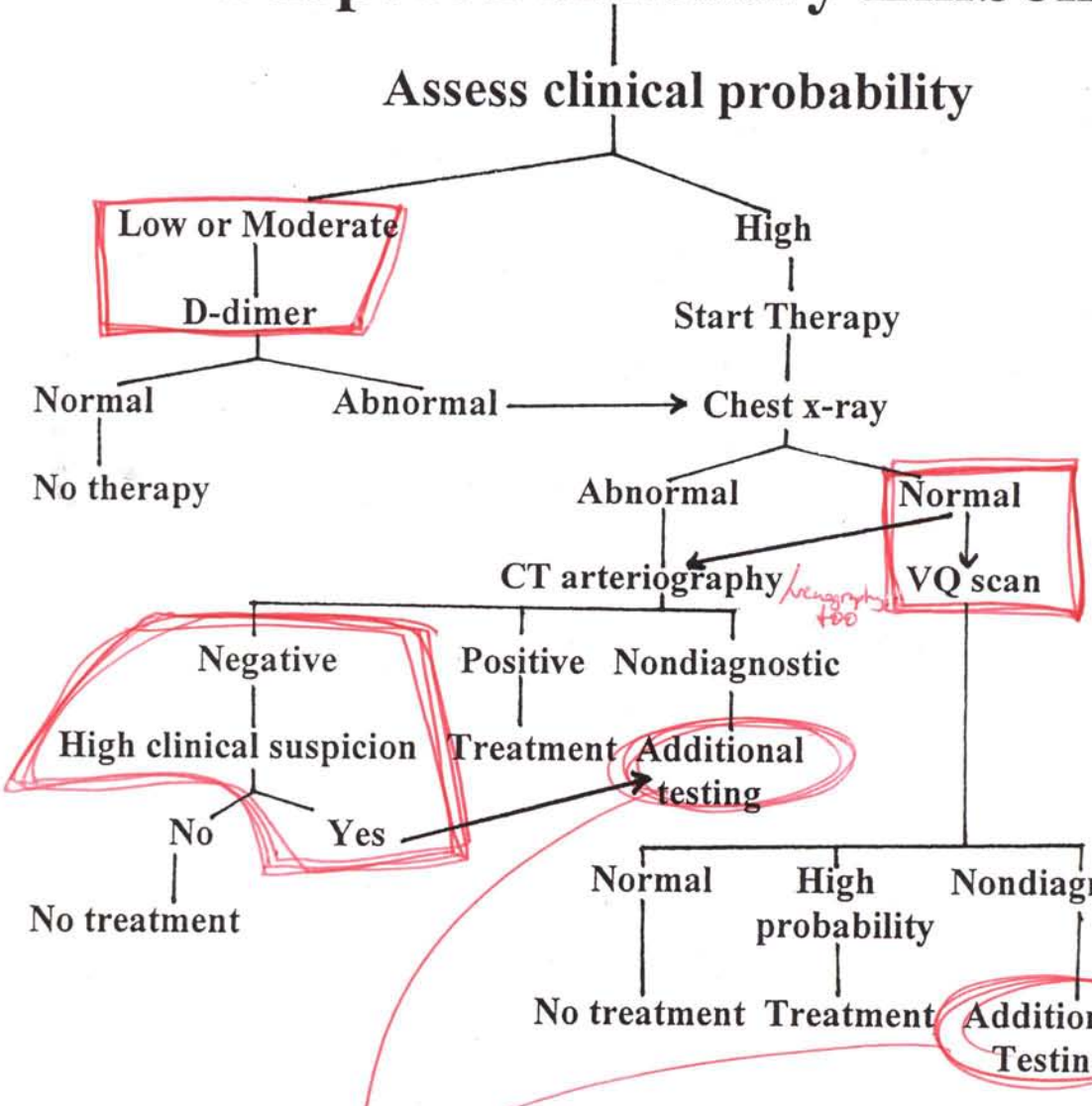
- 2 or > near segmental or larger defects without matching ventilation defects

Low probability: Evaluate for DVT

- Subsegmental perfusion defects
- Single large defect
- Matching defects

PEs take 7/week to resolve w/ anti-coagulation

Suspect Pulmonary Embolism



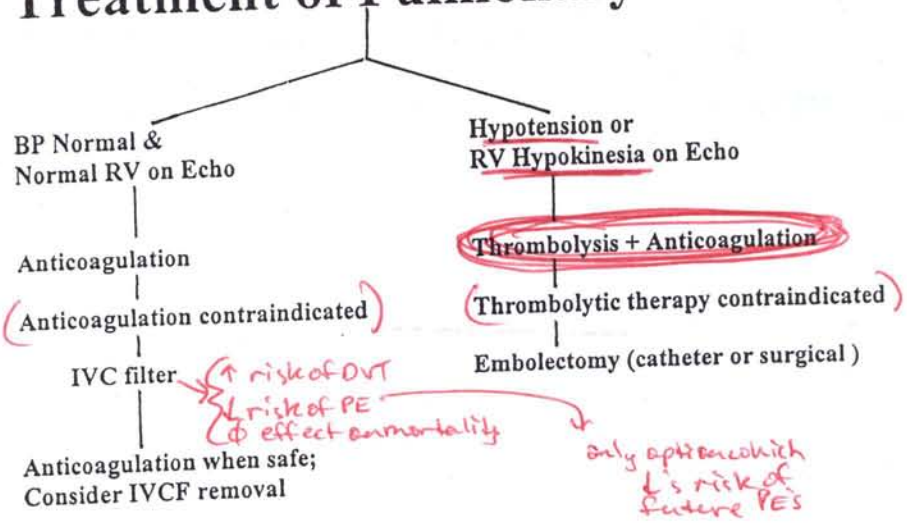
Pulm. HTN
- Tx: Epoprostenol - used in severe cases
pulm. vasodilation + vasc. hypertrophy remodeling

Hereditary Hemorrhagic Telangiectasia (HHT)
- assoc. w/ pulm. HTN (familial)
- recurrent epistaxis
- oral cavity telangiectasias
- AVM's

Nondiagnostic → Low/Moderate probability

Additional testing: Evaluate for DVT by leg ultrasonography, CT venography, magnetic resonance venography, standard venography

Treatment of Pulmonary Embolism



Adjustment of Heparin Dosage

Goal PTT 1.5-2.5 (x control) w/in 24-hrs.

Initial dose	80 U/Kg bolus, then 18 U/Kg/hr
PTT < 1.2 x control	80 U/Kg bolus, ↑ drip by 4 U/kg/hr
PTT 1.2-1.5	40 U/Kg bolus, ↑ drip by 2 U/Kg/hr
PTT 1.5-2.3	No change
PTT 2.3-3.0	↓ drip by 2 U/Kg/hr
PTT > 3.0	Hold infusion 1 hr., I rate 3 U/Kg/hr

Contraindication to Anticoagulant Therapy

Absolute Contraindications

Active bleeding
Severe bleeding diathesis or platelet count < 20000
Neurosurgery, ocular surgery, or intracranial bleeding within past 10 days

Relative Contraindications

Mild-to-moderate bleeding diathesis or thrombocytopenia
Recent major trauma
Brain metastases
Major abdominal surgery within past 2 days
Gastrointestinal or genitourinary bleeding within the past 14 days
Endocarditis
Severe hypertension (systolic >200 mm Hg, diastolic >120 mm Hg)

Pancoast Tumor
- (R) UL mass
- (R) UE weakness
- Horner's syndrome

Ptosis w/ constricted pupil (miosis)

Mesothelioma
- assoc. w/ asbestos
- pleural-based (usually LL dis.)

Types of Lung Cancer

Dx:
- chest CT
- PET Scan

- Small cell (oat cell) — most common; assoc. w/ muscle weakness; central masses; assoc. w/ SIADH; ↑ ADH hormones
- Squamous cell — ↑ pTH → Hypercalcemia
- Adenocarcinoma — peripheral nodules
- Large cell

β-carotene → ↑'s risk of lung cancer in smokers

Staging of Non-Small-Cell Lung Cancer

Local		Locally Advanced		Advanced	
1A	T1 N0 MO	IIB	T2 N1 MO	IIIB	T4 Any N M0
1B	T2 N0 M0	IIIA	T1 N2 M0	IV	Any T Any N M1
IIA	T1 N1 M0		T2 N2 M0		
			T3 N1 M0		
			T3 N2 M0		
		IIIB	Any T N3 M0		

Bronchioloalveolar Cell Carcinoma
- nodular pulm. infiltrates
Tx: ① 1st line: Platin + -Taxel
if ↓response then Erlotinib (EGF receptor inhibitor)

T1: <3cm, surrounded by lung or pleura; no tumor more proximal than lobe bronchus
T2: >3cm, involving main bronchus >2cm distal to carina, invading the pleura
T3: Tumor invading the chest wall, diaphragm, mediastinal pleura, pericardium, main bronchus <2cm distal to carina
T4: Tumor invasion of mediastinum, heart, great vessels, trachea, esophagus, vertebral body, carina; separate tumor nodules; malignant pleural effusion

Soft tissue sarcoma w/ mets → surgical excision (even w/ multiple mets)
- 5-year survival 25-30%

N0: No nodes
N1: Ipsilateral peribronchial or hilar nodes
N2: Ipsilateral mediastinal or subcarinal nodes
N3: Contralateral lung nodes or any supraclavicular nodes

M0: No distant metastasis M1: Distant metastasis

Treatment of Non-Small-Cell Lung Cancer

- ✓PFT's to assess reserve prior to surgical consideration
- Also ✓ Brain + Bone scans

Stage	Primary Treatment	Adjuvant Therapy
I	Surgical resection	Chemotherapy
II	Surgical resection	Chemotherapy ± radiation
IIIA (Resctable)	Preoperative chemotherapy followed by surgical resction or surgical resection	Radiation therapy + chemotherapy (If not given before) or radiation alone
IIIA (Unresctable) or IIIB	Chemotherapy + radiation	None
IV	Chemothearapy, surgical resection of solitary brain metastasis, surgical resection of primary T1 lesion	

Multiple Mets w/ poor performance status → Hospice Referral

Contraindication of Surgery in Lung Cancer

1. Tumor invasion of heart, great vessels, mediastinum, esophagus, vertebral body, carina or lesion within 2 cm of carina
2. Malignant pleural effusion
3. Involvement of supraclavicular nodes or contralateral lung nodes → N3
4. Distant metastasis
5. SVC syndrome
6. Vocal cord or phrenic nerve paralysis
7. Small cell cancer
8. Poor cardiac or pulmonary reserve ($PO_2 < 50$, $PCO_2 > 45$)

Treatment OF Small Cell lung Cancer

use chemo for both → small cell is presumed to be systemic w/ micro mets even if it appears isolated

Limited disease
Confined to one hemithorax, and regional nodes(hilar, mediastinal, subcarinal, scalene & supraclavicular)

→ Chemotherapy + Chest radiation

→ Cranial radiation to complete tumor responders

Extensive Disease (distant multiple mets)

All others

Brain mets → whole Brain Rad Tx

Chemotherapy (very chemosensitive)

~50% w/ palliative 1-2yrs. of survival

Superior Vena Cava Syndrome

- swollen neck/face
- periorbital edema
- dilated chest wall veins

Causes: Malignancy (65%)... Lung cancer, lymphoma, thymoma, metastatic
Mass in the middle or anterior mediastinum to the right of the midline
Benign causes (35%)... Thrombosis, aneurysm, inflammatory process

S/S: Increased venous pressure in the upper body
Edema of head, neck, and arms distended veins, cyanosis
Edema of larynx and Pharynx
Cough, hoarseness, dyspnea, stridor, dysphagia
Cerebral edema
Headache, confusion, coma, dizziness

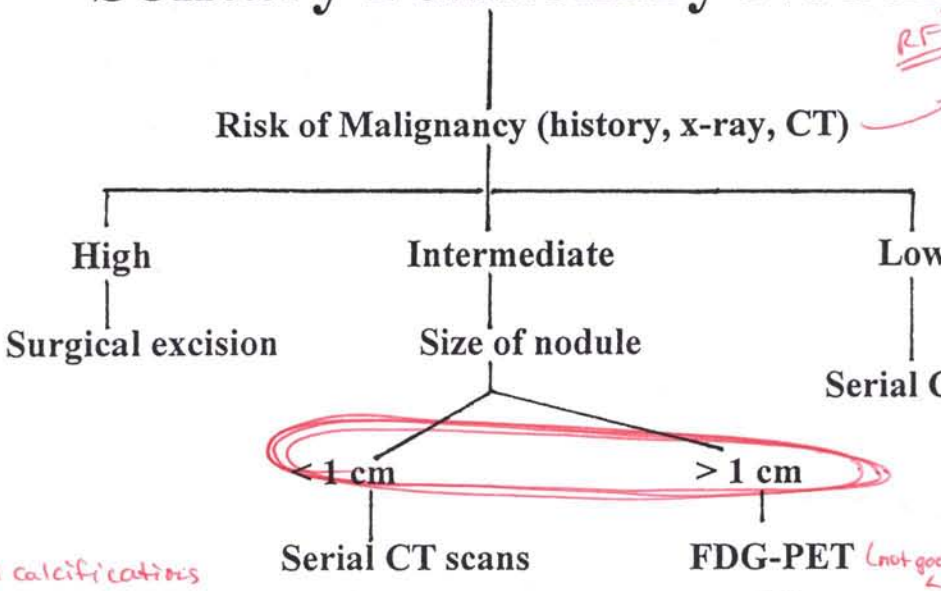
Diagnosis: CT with contrast most useful, venography, MRI
Biopsy of the supraclavicular node, sputum cytology, pleural fluid cytology, bronchoscopy and biopsy, transthoracic needle biopsy, mediastinoscopy, mediastinotomy

Treatment: Radiation, chemotherapy or both depending upon tumor type and stage of tumor
Intravascular stent (can be placed before tissue diagnosis)
Thrombolytics and anticoagulation for thrombosis

wound Botulism
- assoc. w/ "black tar" heroin
- bulbar necro abnorms
- SQ abscesses
- Clostridium botulinum

Tx: Type A Equine Antitoxin + Abx

Solitary Pulmonary Nodule



Low-Risk
- ϕ Δ in 2yrs.
- dense central calcifications
- popcorn calcifications

Malignancy suggested

Yes → Surgical excision

NO → Serial CT scans

Most common benign lung tumor
↓
Hamartoma (slow growing)
↓
on CT → focal area of low and high attenuation w/in the mass (fat/calcium)

Ex.) 35 y.o. woman w/ (L) pneumothorax
H/o (R) pneumothorax x 2 months ago
CTube → post-expansion CXR w/ ↑'d interstitial markings
PFTs → moderate obstruction
CT → diffuse cystic Δ's in (B) lung parenchyma

Dx: Pulm. Lymphangioleiomyomatosis
- characterized by immature smooth muscle cell proliferation
- poor prognosis

Tx: - ϕ

Serial CT Scans

Size	Low Risk	High Risk (smoking or other risk factors)
< 4 mm	None	At 12 months once only
4-6 mm	12 months once	6-12 months, then at 18-24 months
6-8 mm	6-12 months then at 18-24 months	3-6 months, then at 9-12 and 24 months
> 8 mm	3, 9, 24 months	3, 9, 24 months

Ex.) Hemoptysis
CXR → (R) UL density surrounded by air - density Δ's positions w/ various chest views

Fungus Ball (Aspergilloma)

Tx: - surgery for severe hemoptysis

Ex.) Asthmatic w/ recurrent cough + wheezing, low grade temp, brown sputum, eosinophilia + responds to Abx, bronchodilators + steroids

Nutrition Requirements
25-30 kcal/kg/day non-protein
1-1.5 kcal/kg/day protein

Critical care
SC TLC x 5 days and still requiring IVF's
- ϕ need to Δ central lines (only peripherals need changing)

Allergic Bronchopulmonary Aspergillosis
- sputum colonized
- IgE - very ↑ (>1000)
- Eosinophilia
- IgG / IgE Ab's (+)
- HRCT → Bronchiectasis
- (+) skin test
- H/o asthma

Tx: steroids + Itraconazole x 16 wks.