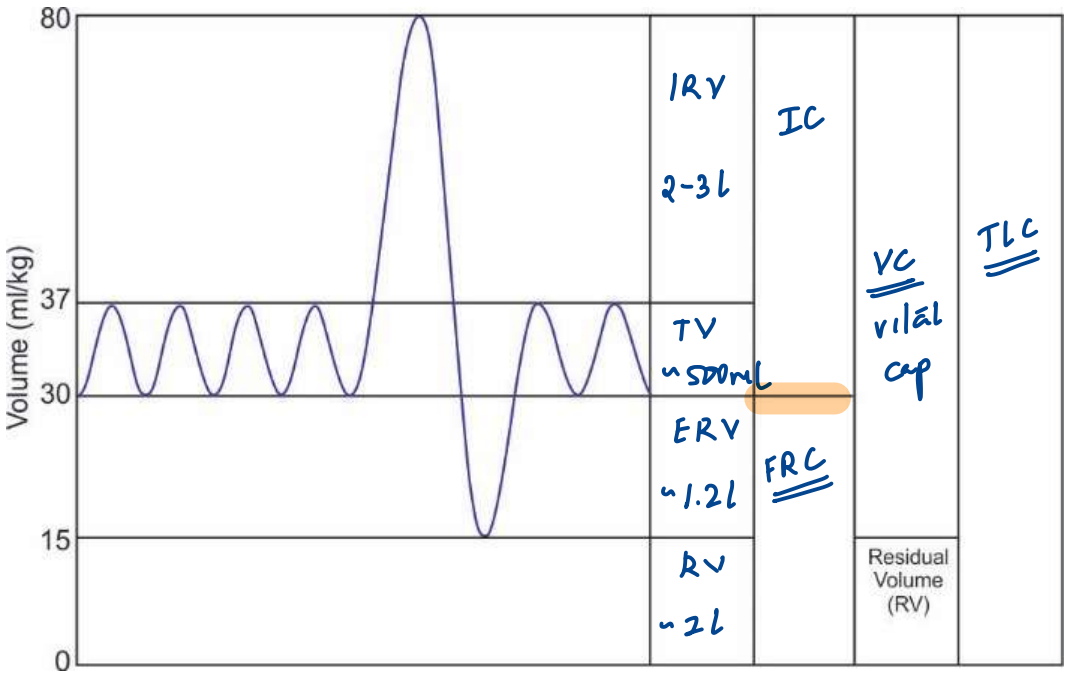
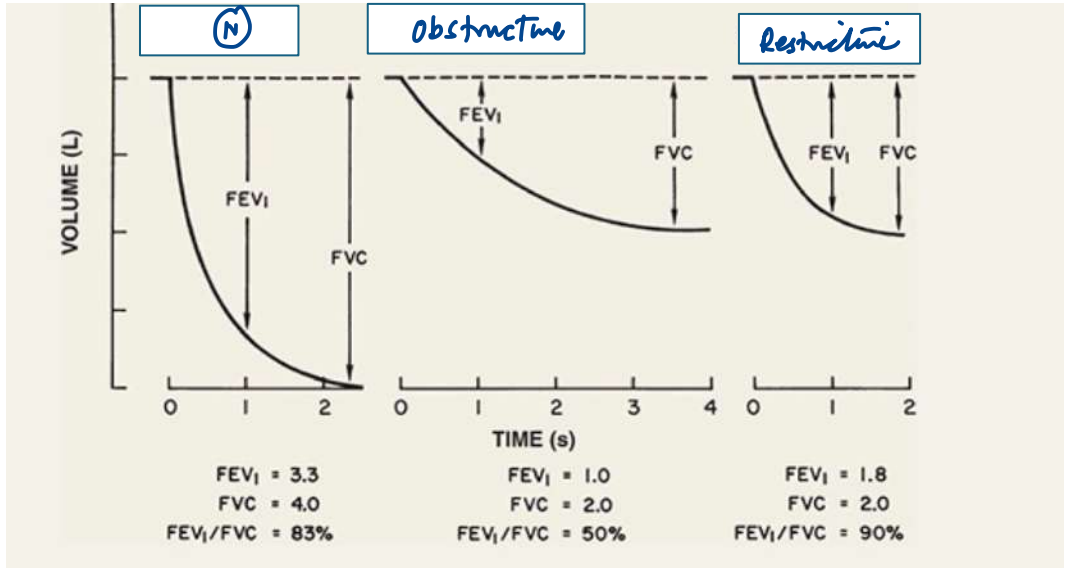
INTEGRATED RESPIRATORY SYSTEM

SPIROMETRY

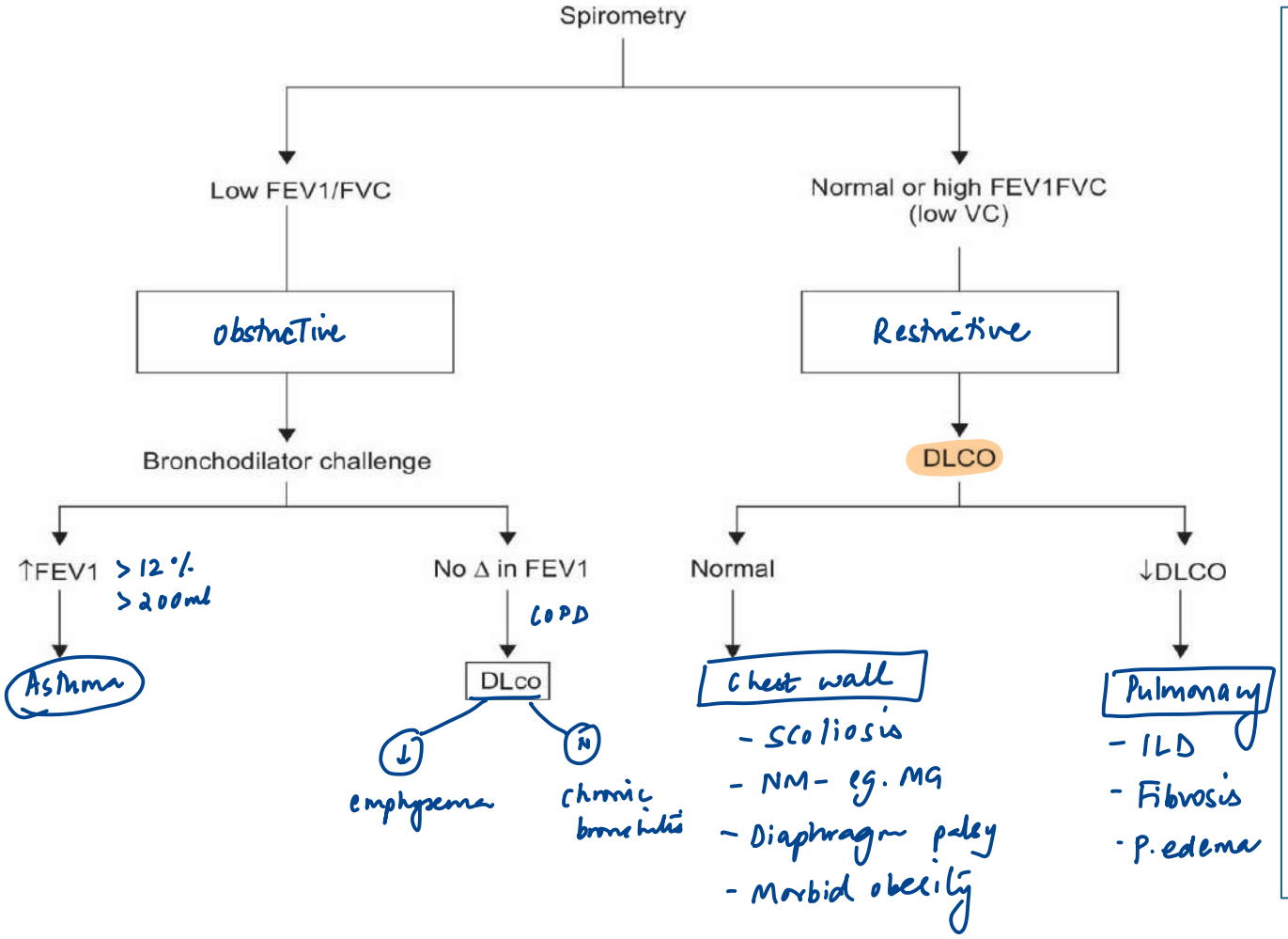


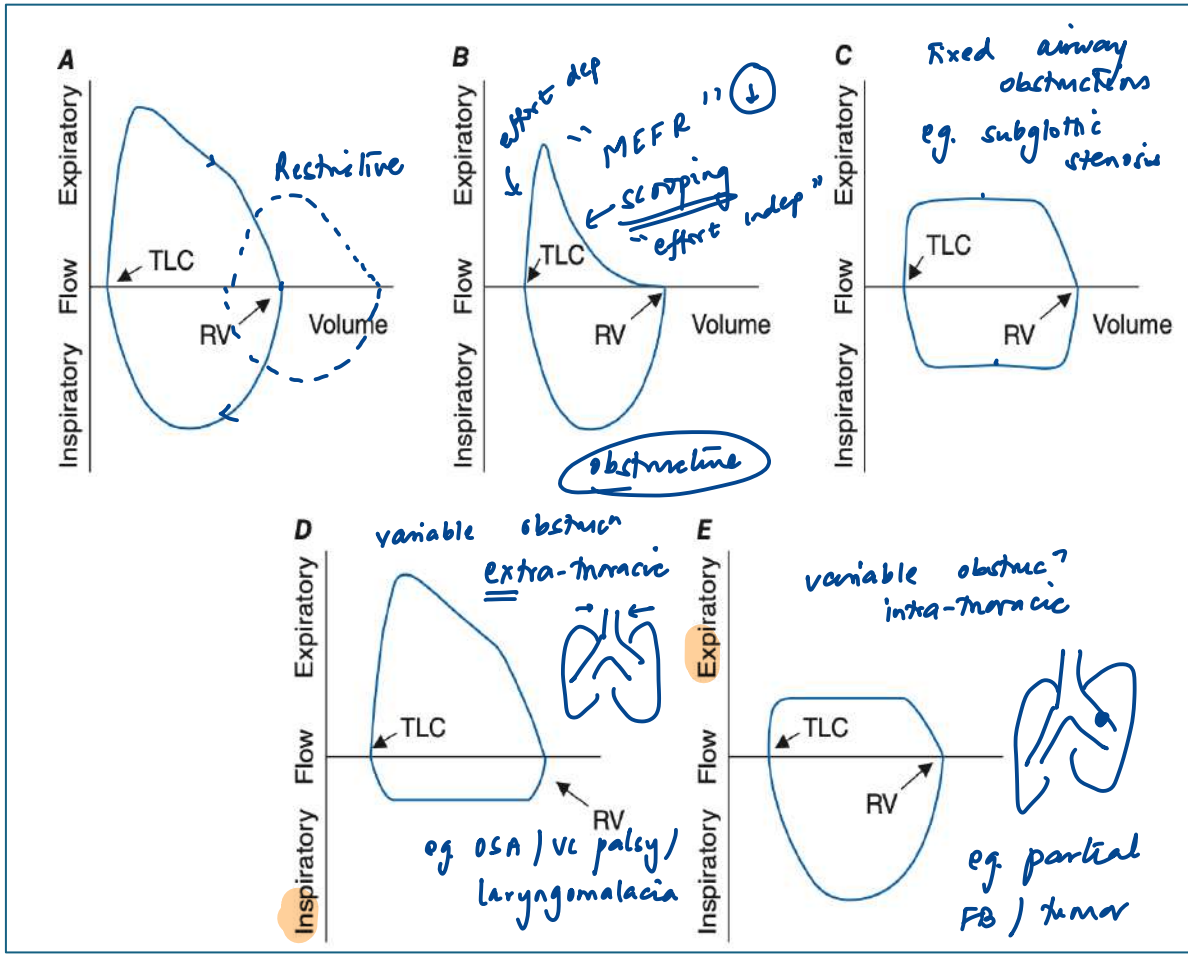


Parameter	Obstructive Lung Disease	Restrictive Lung Disease
RV	↑ "air trapping"	↓
FRC	↑	↓
TLC	↑	↓
FEV_1 (N:>80%)	↓	N – ↓
FVC(N:>80%)	N – ↓	↓↓
FEV_1/FVC (N:>70%) (Tiffeneau–Pinelli index)	↓ "Low"	N – ↑

Residual volume :

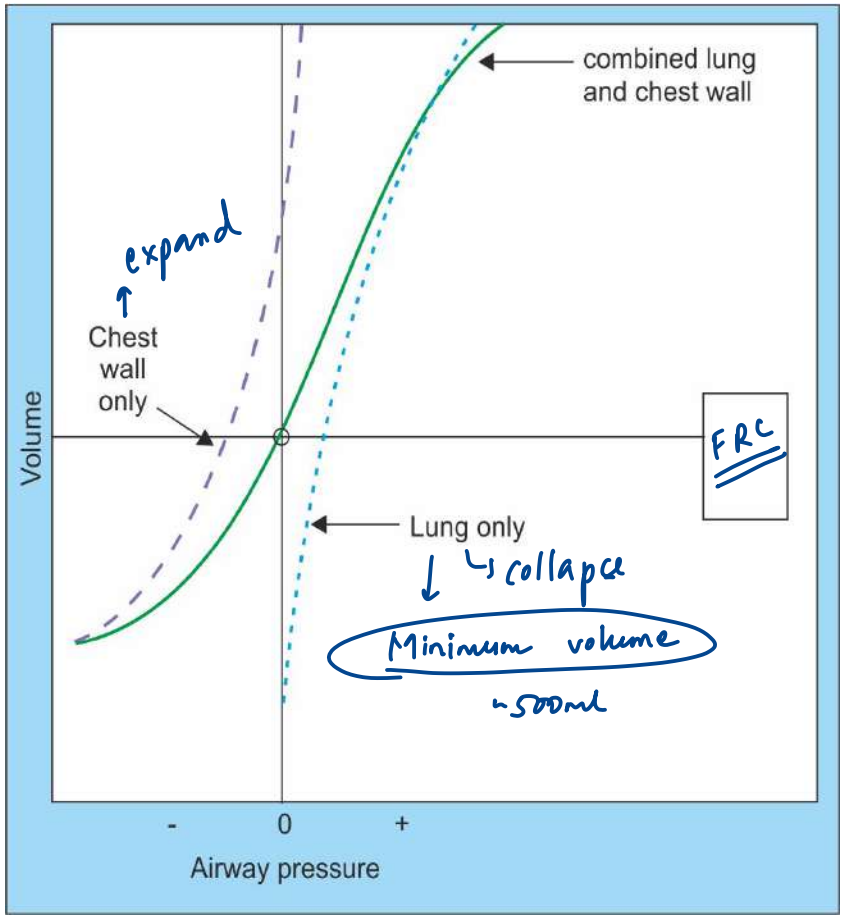
Helium dilution/ Nitrogen washout /Body plethysmography

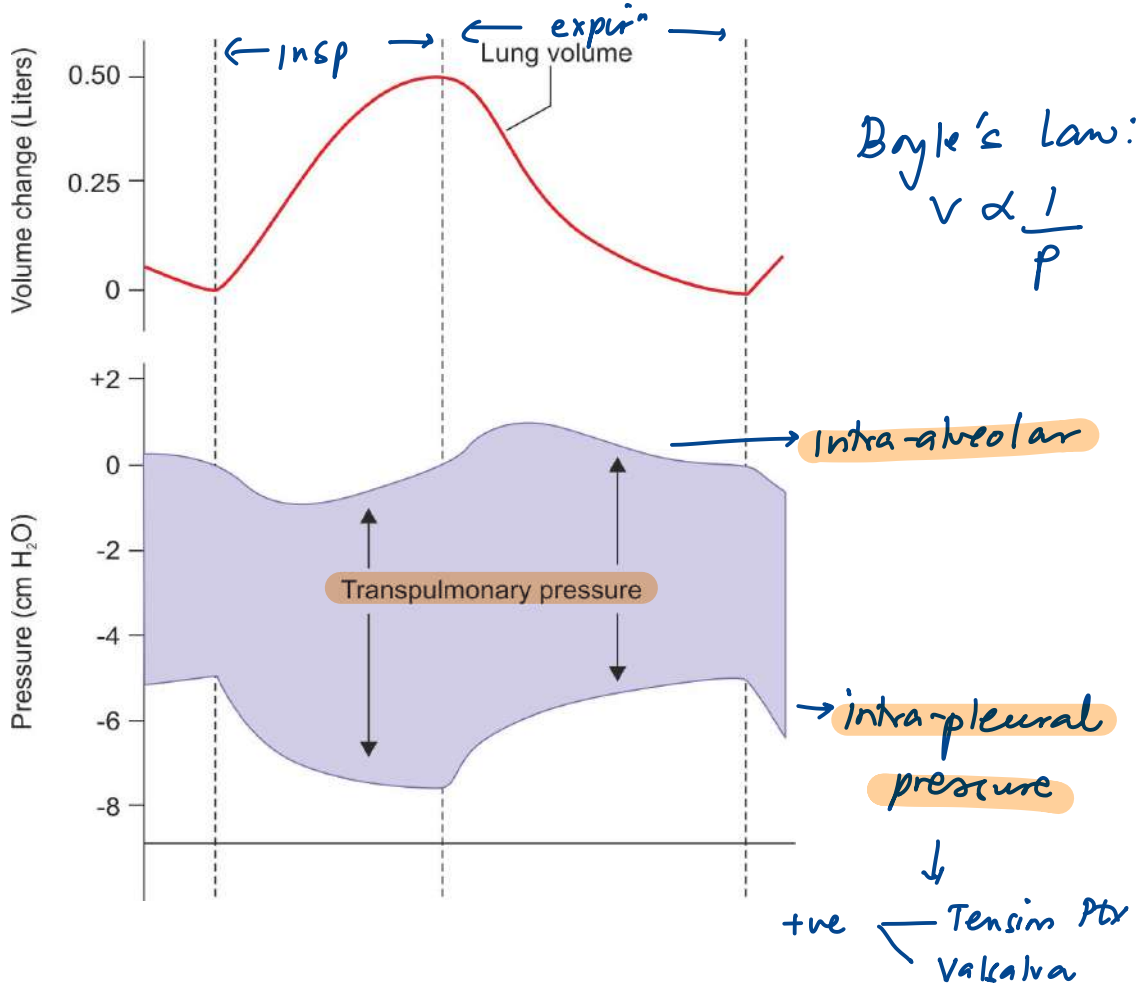




Low MIP / MEP: Resp muscle weakness
High DLco: polycythemia / DPH = DAH - hge = MPA, Goodpasture, WG
Low Dlco with normal FEV1/FVC: PAH, ad / anemia

Respiratory physiology graphs

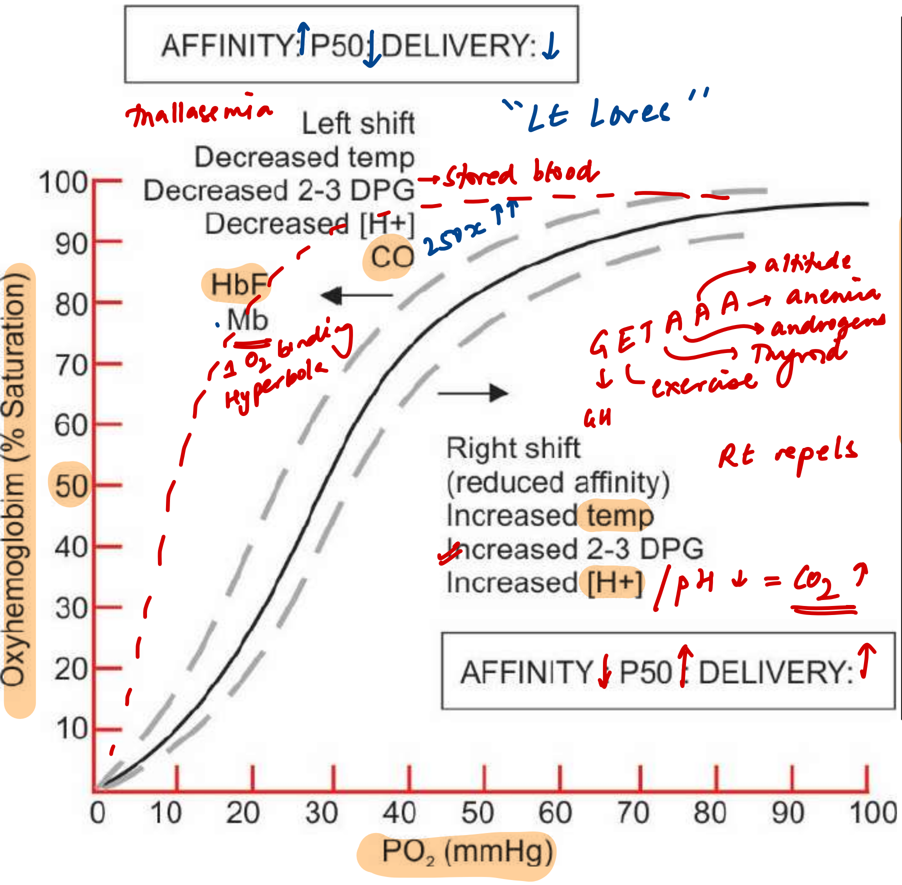


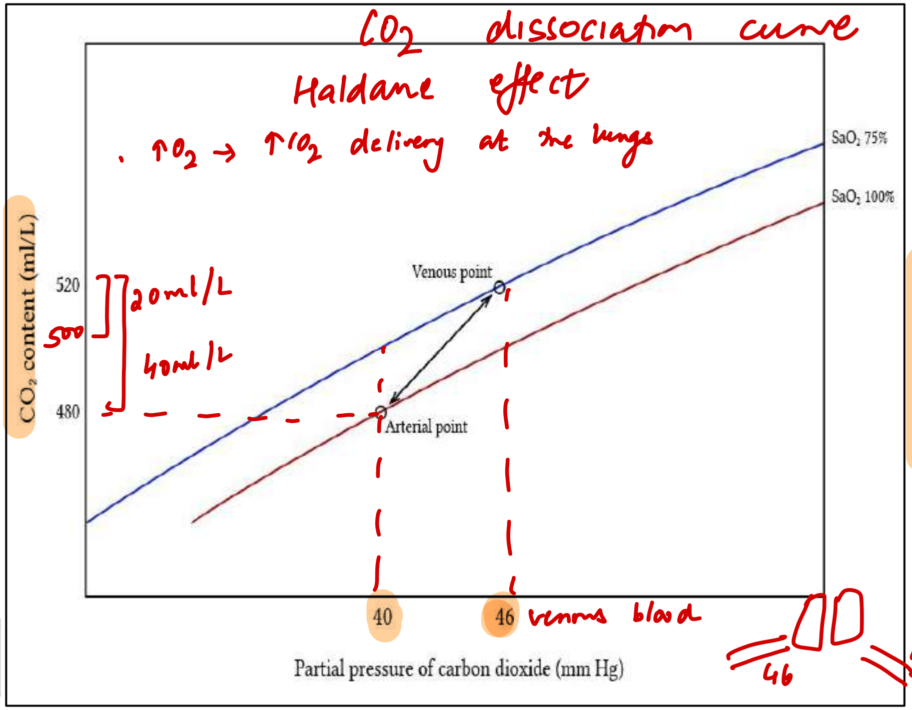


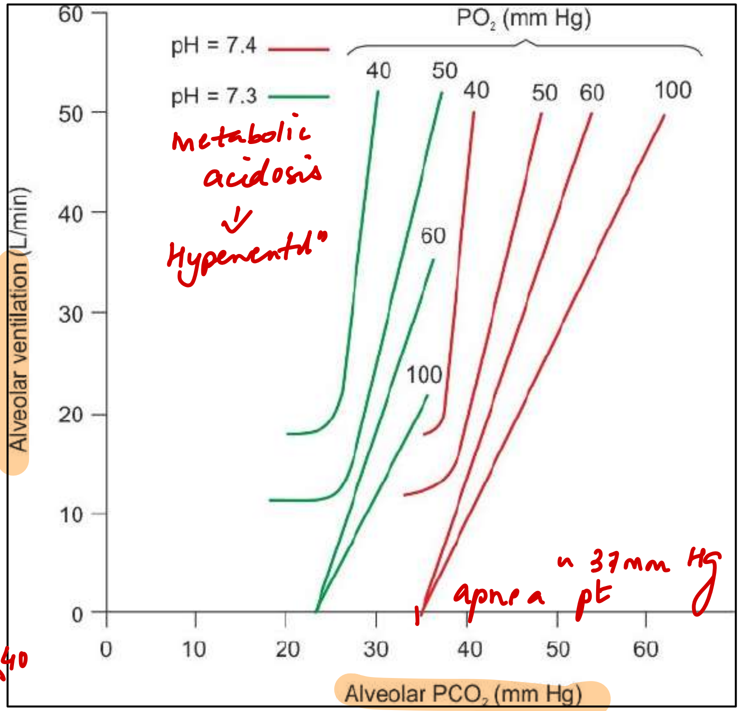
Closing volume (CV): lung volume where small airways in the lower lungs begin to close during expiration

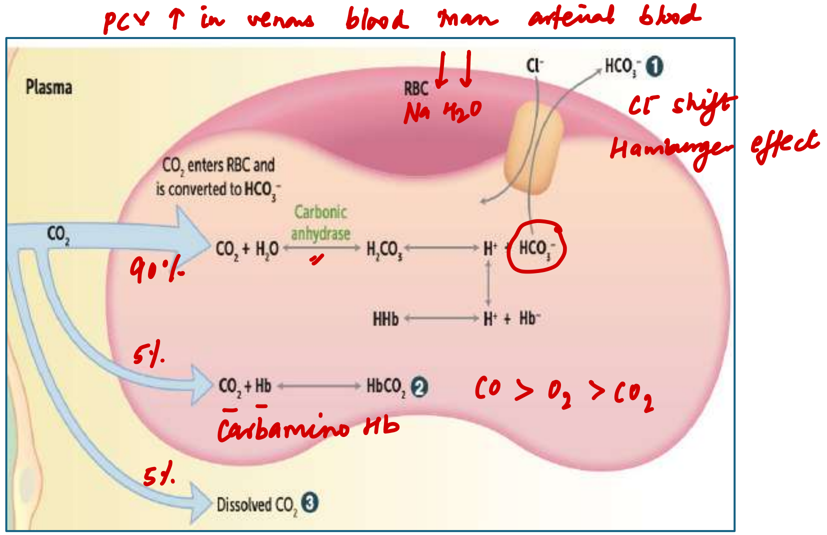
Increased in: elderly / smokers / COPD / asthma / obese / supine

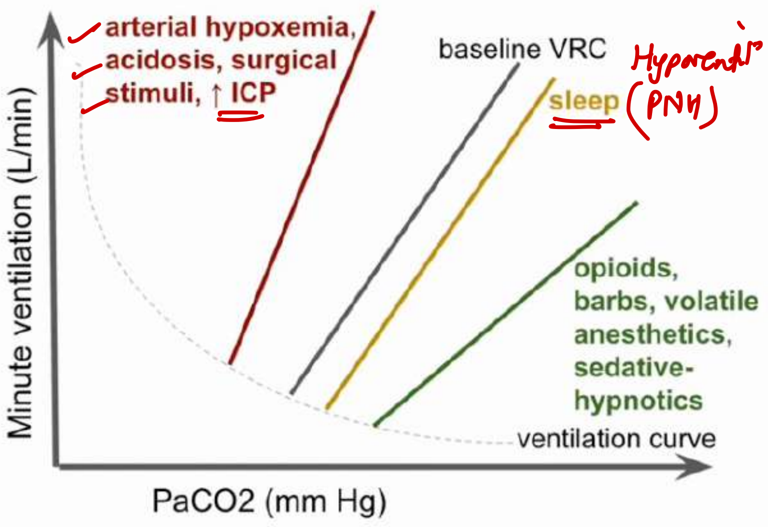
Closing Capacity: CV + RV











Shape: Sigmoidal

Positive co-operativity

P50: 26mm Hg

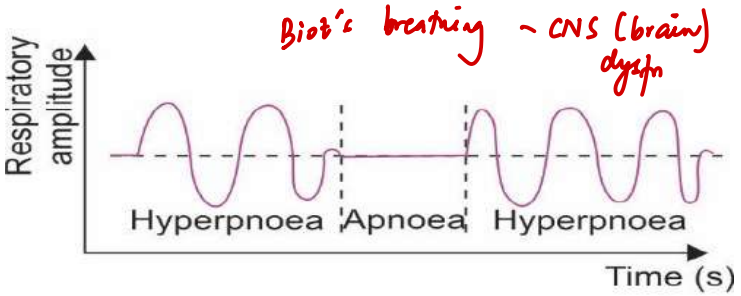
2,3 DPG binds to: β-globin

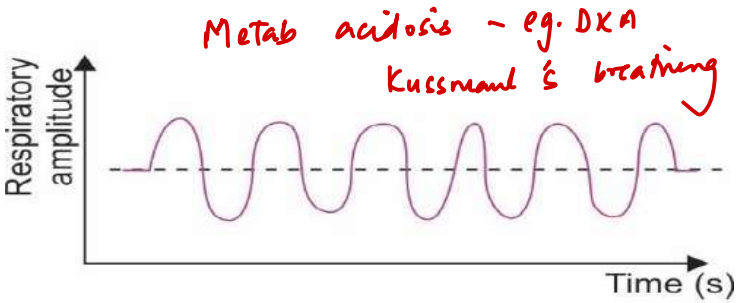
R (relax) → T (taut) state
repel

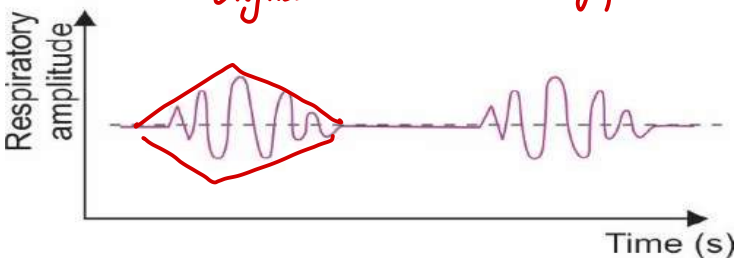
O_2 — Hb — O_2, O_2, O_2

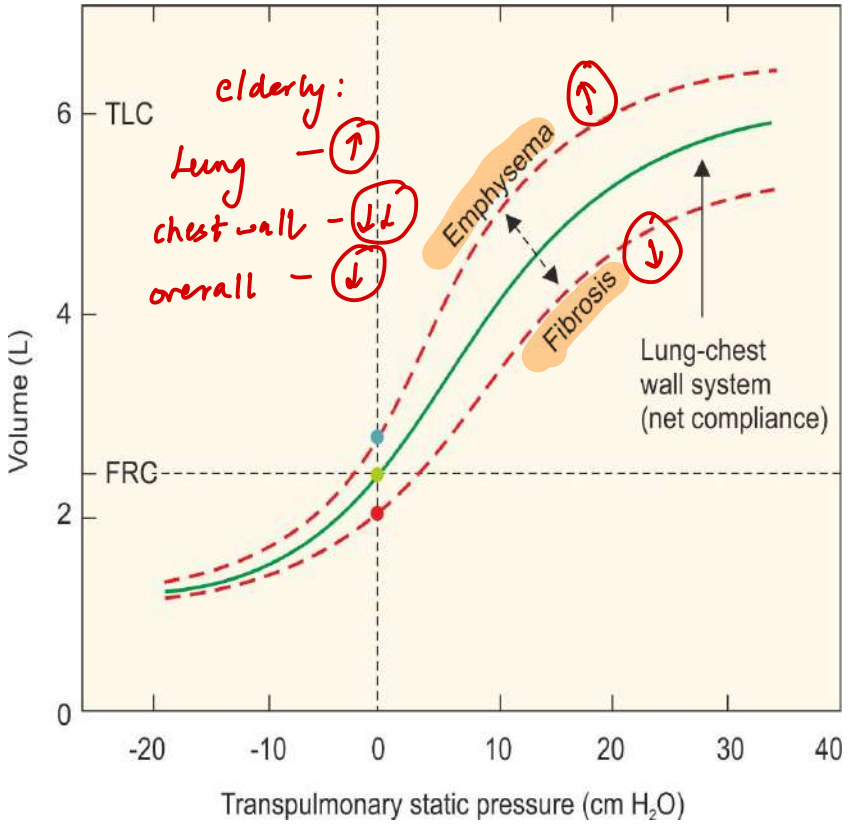
BOHR effect:

Partial pressure of carbon dioxide increases-Reduced affinity of O2







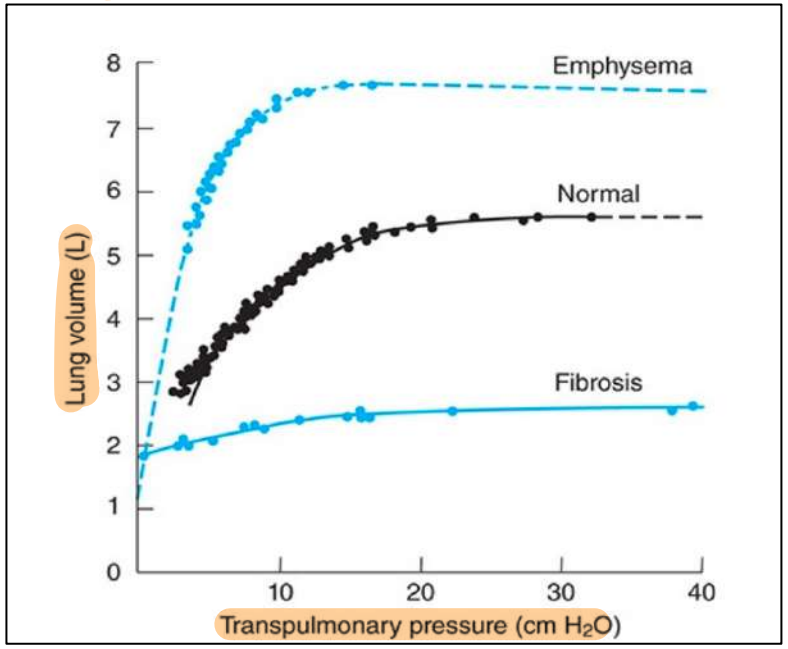


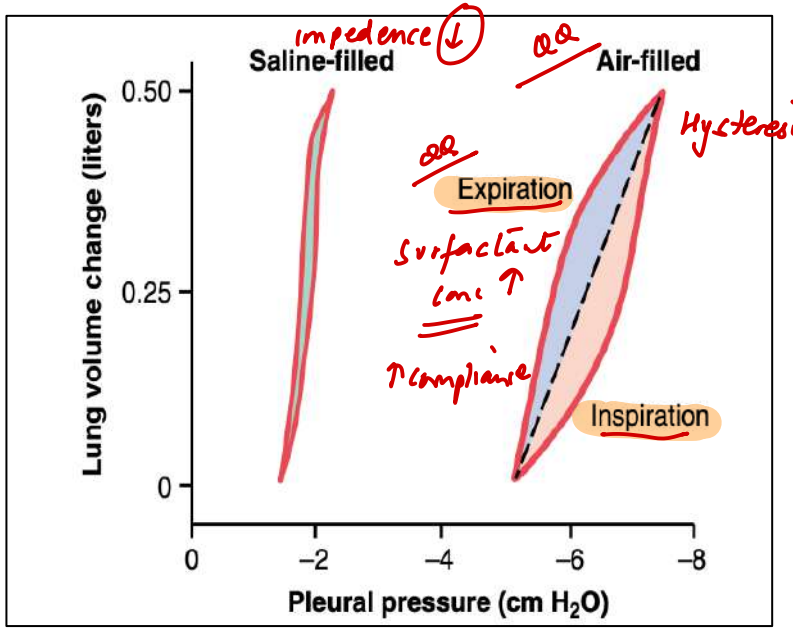
Surfactant: Compliance ↑
Surface tension ↓

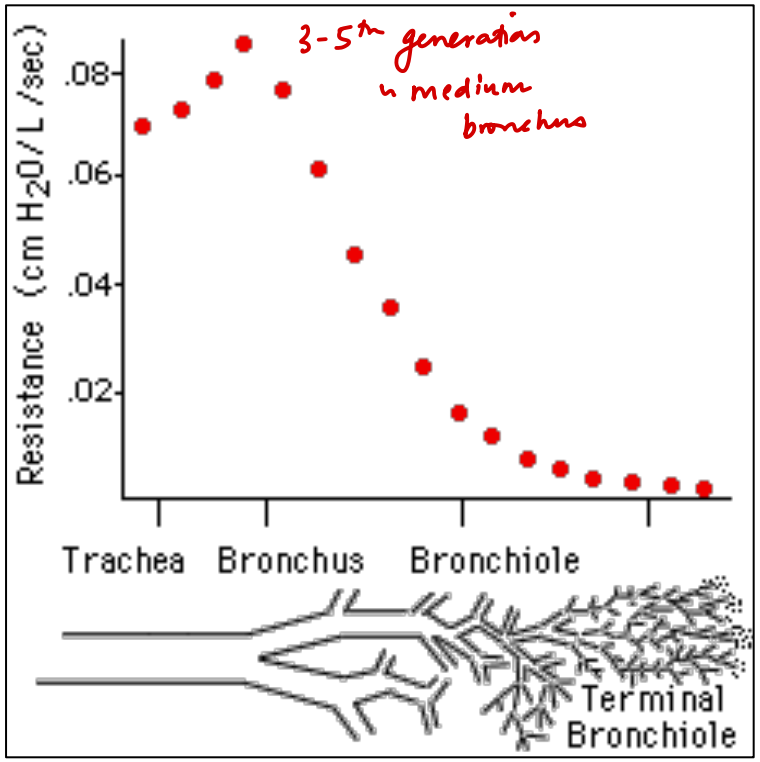
Compliance = $\frac{\Delta V}{\Delta P}$

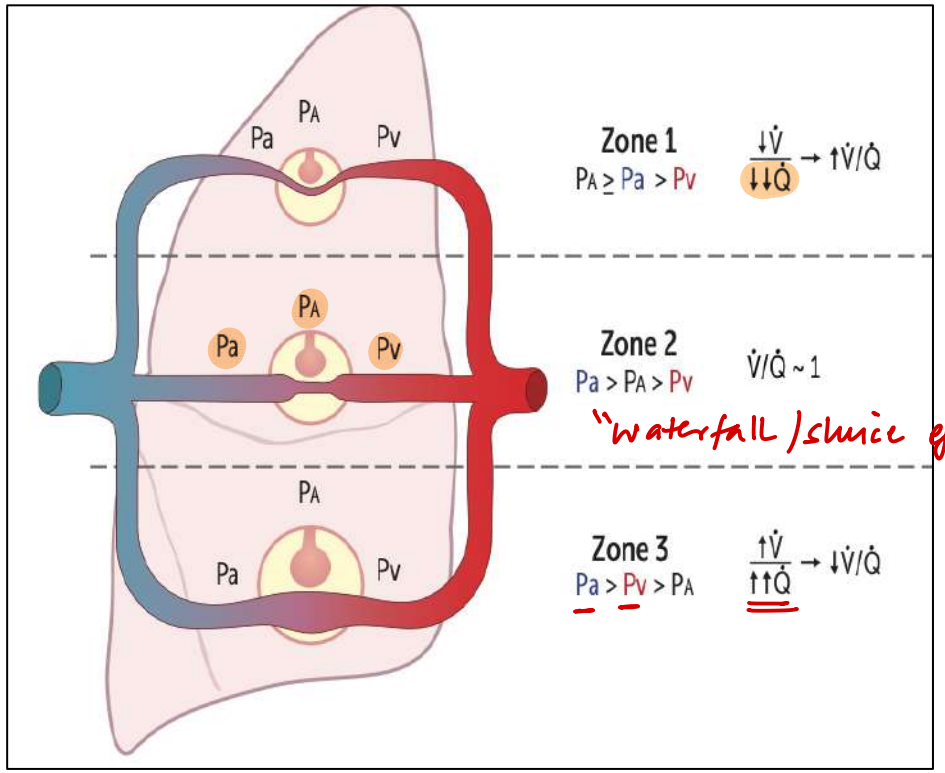
HMD / RDS
Surfactant ↓
compliance ↓
collapse ↓

= $\frac{9}{cm^3}$





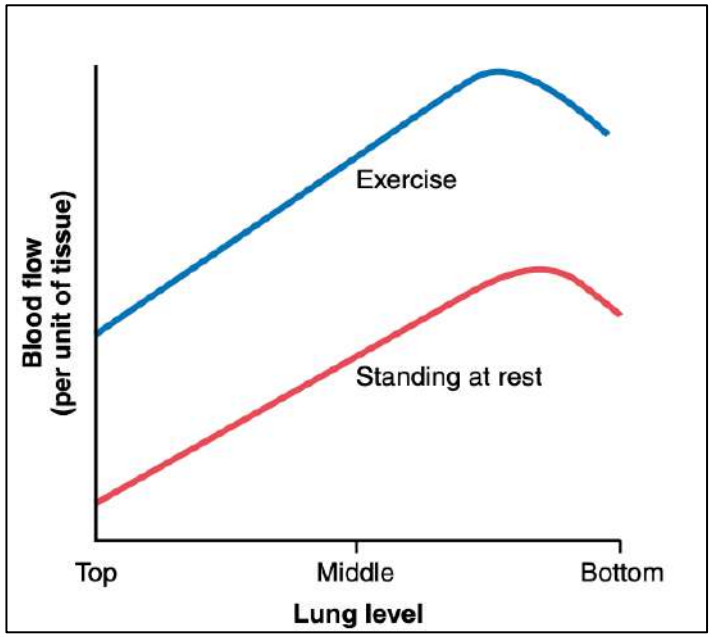




PPV / Hypovolemia: Zone 1

Exercise: Zone 3

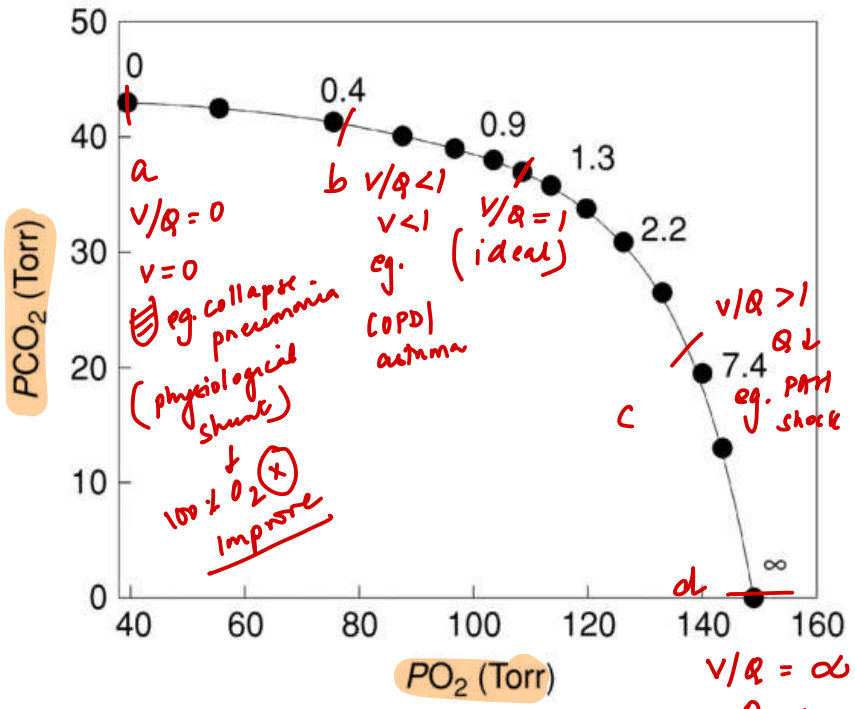
Supine, exercise: V/Q matching

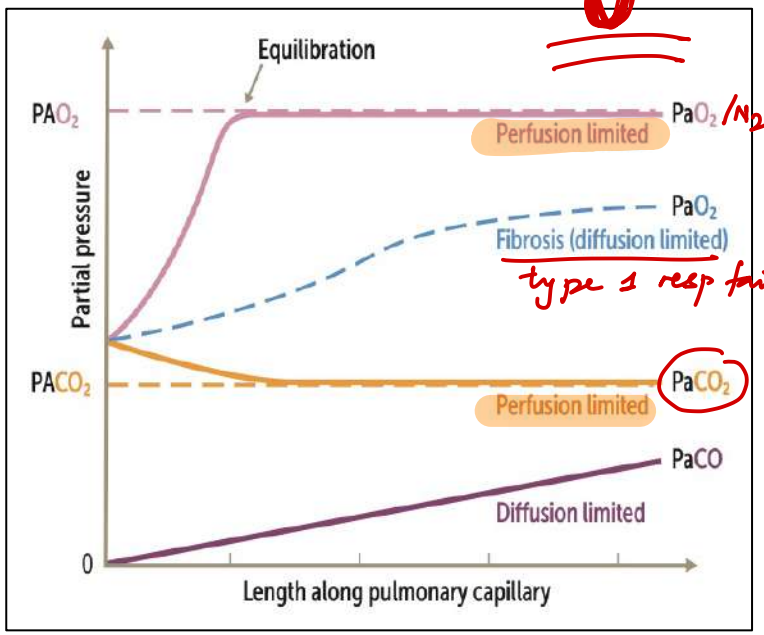


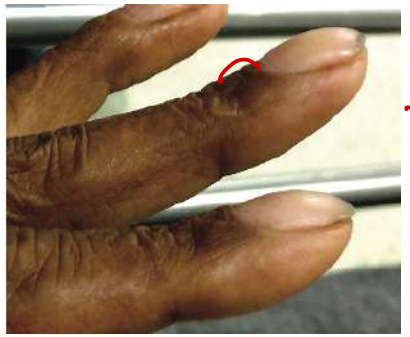
0-16
conducting zone
(terminal bronchiole)
↳ anat dead space
↳ 150ml

17 - 23rd generation
(resp bronchiole, alv)
↳ ventilatory zone

$R \propto \frac{1}{r^4}$ (ET tube - r ↓ R ↑↑)







clubbing
nail bed – plate
Lowibond >180°

↓ O_2 – PDGF / VEGF ↑

Causes → Ca lung / abscess / ILD

✗ COPD / asthma.

HYPOXIA

A

a

A–a gradient: Normal

↓ Inspired Oxygen Tension (P_iO_2)

↑ altitude

$P_iO_2 = F_iO_2 \times (P^B - P^{H_2}O)$

21% 760 ↓↓ − 47 mm

↑ altitude

Hypoventilation (↑ $PaCO_2$)

A–a gradient: Increased

Diffusion Limitation

- Pulmonary fibrosis

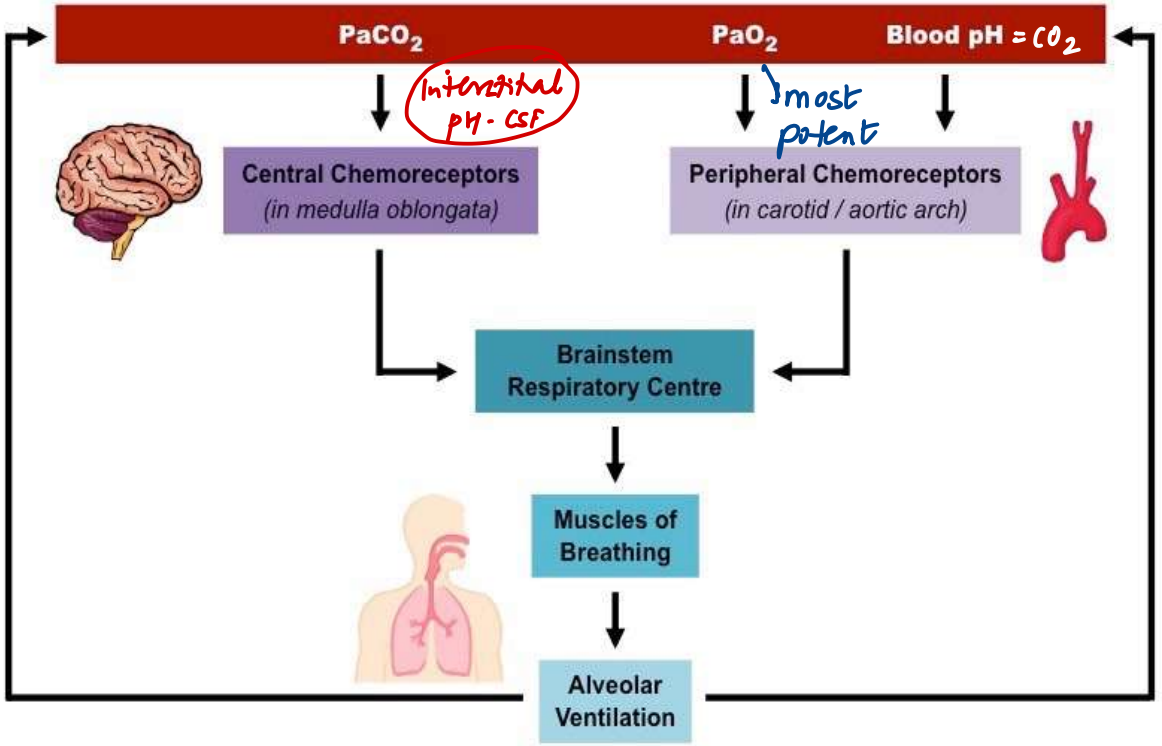
V/Q Mismatch

- Pulmonary edema
- Pulmonary embolism

Right-to-Left Shunt

- Anatomic shunt (cardiac)
- Physiologic shunt (e.g., ARDS)
- Does not correct fully with 100% oxygen

≠



Altitude physiology: Hypoxia → Peripheral → Hyperventin
Acid-base: Resp alkalosis
Kidney compensation 48-72hrs
Rx of acute mountain sickness: "Acidazolamide"

↳ Rt shift ↑RBC
2,3BPG/ EPO/ VEGF: ↑ – ↑ mitochondria
PVR: Hypoxia – K^+ channels close – depolarisn → Ca^{2+} influx → VC
02 sensitive K channels (VS ATP-sn in systemic)
= ↳ ↓ATP – ↓K^+ open → repolarn ↳ ↓Ca^{2+} influx
HAPE: pulm VC ↑↑
Rx: O_2 + immediate descent + CCB (vd)
HACE: Cerebral vasodil aq ↳ ↑Hydrost pr → cerebral edema
Rx: O_2 + immed descent + dexamethasone (steroids) leakage

LUNG REFLEXES aa

Hering–Breuer inflation reflex
Prolonged inspiration (TV ≈ 1500 mL) -> ⊖ further inspirn
Myelinated vagal fibres (slow-adapting)

Head's paradoxical reflex
Prolonged inspiration -> ⊕ inspiration — 1st breath

J reflex aa
Raised capillary pressure -> apnea
Unmyelinated vagal C fibres

Space physiology

Positive G: VR/Cerebral perfusion ↓
"Blackout"
Negative G VR/Cerebral perfusion ↑
"Red eyes"

Decompression sickness / Caisson's disease

↓ pressure ↑ – N_2 dissolves (Henry law) if ascent fast N_2 bubbles "narcosis"
Bends/ chokes/ Hemoconcentration aa
Rx: Hyperbaric O_2 + ascent slow

FORMULAE

MINUTE VENTILATION = TV × RR

ALVEOLAR VENTILATION = (TV − dead space) × RR

$$V_D = V_T \times \frac{Paco_2 - P_Eco_2}{Paco_2}$$

OXYGEN CARRYING CAPACITY OF BLOOD

C_aO_2 = Hb-bound O_2 + Dissolved O_2

$C_aO_2 = (O_2 \text{ carrying capacity} \times S_aO_2) + (P_aO_2 \times 0.0031)$

$(1.34 \times Hb \times Sa\,O_2)$

	Hb CONCENTRATION	Sao_2	Pao_2	TOTAL O_2 CONTENT	
CO poisoning / MethHb	N	↓	N	↓	Anemic hypoxia
Anaemia	↓	N	N	↓	"
Polycythaemia	↑	N	N	↑	
Cyanide toxicity	N	N	N	N	Histotoxic hypoxia

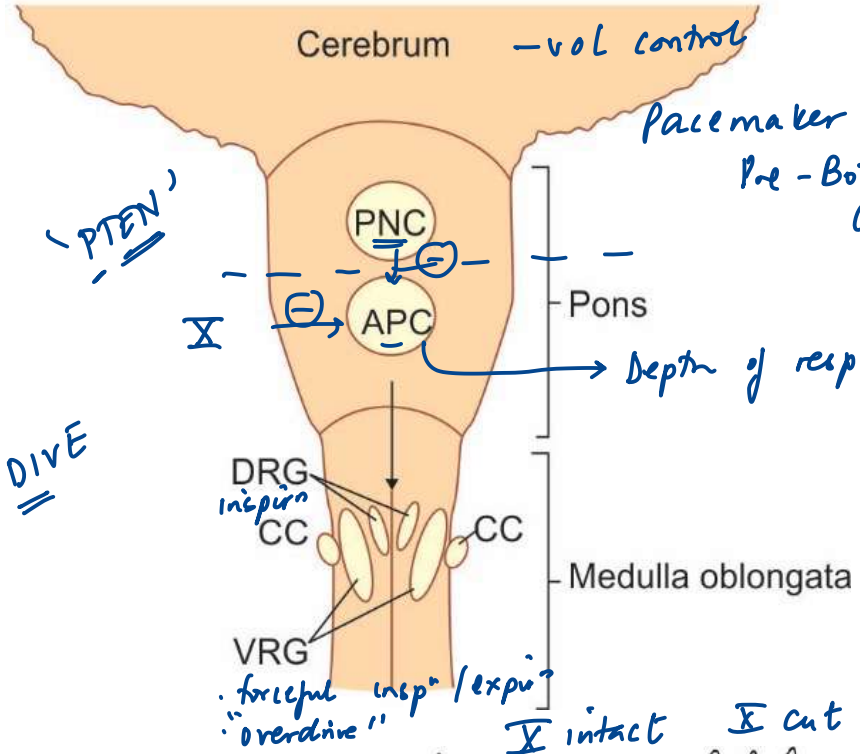
Lt shift

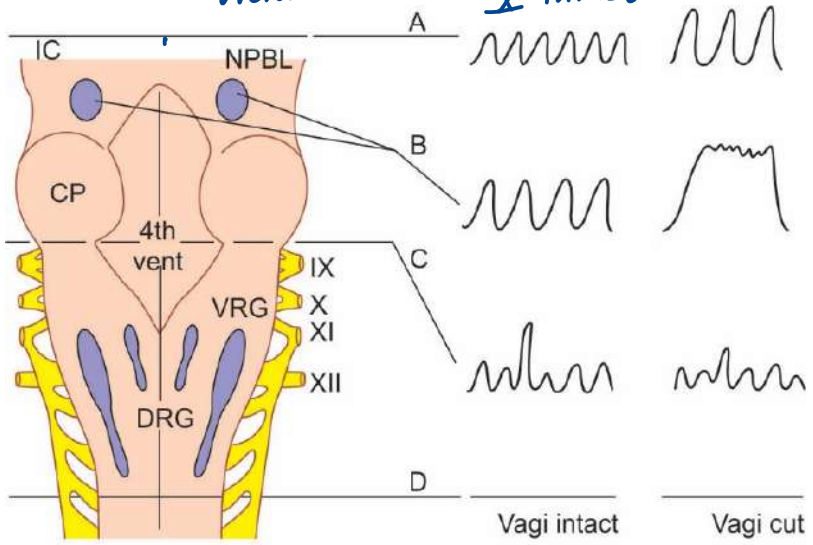
$Fe^{2+} \rightarrow Fe^{3+}$

ETC IV ⊖

- Hypoxic hypoxia (PO_2 ↓) eg. ILD
- Stagnant hypoxia – CO ↓↓ – eg. CHF

RESPIRATORY REGULATION



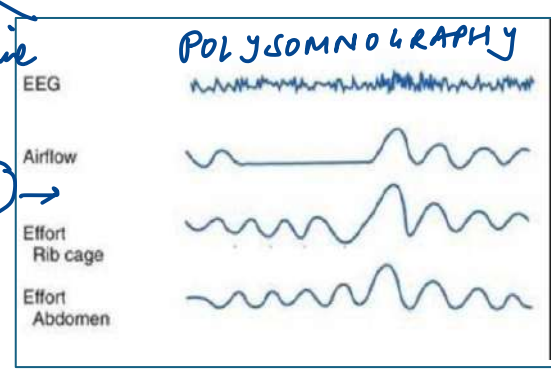


Transection	Effect
ABOVE PONS	X intact: vol control X cut: ↑ depth
MID-PONS	X intact: ↑ depth X cut: apneusis
PONS-MEDULLA	Irregular respn
BELOW MEDULLA	Cessn of respn

Ondine's curse
Cerebrum - vol control
Brainstem disorder

PaO2 normal during day - sleep apnea

- Central sleep apnea → resp drive
- obstructive sleep apnea → OSA



Obesity = Pickwickian Sx
Hypoventilation
PaCo2 high during day and night

RESPIRATORY FAILURE

TYPE 1
HYPOXEMIC

eg. · ILD
· P. edema
· emphysema

- PaO_2 ↓
- $PaCO_2$ N / ↑

TYPE 2
HYPERCAPNIC

eg. · Chronic bronchitis
Hypoventilation

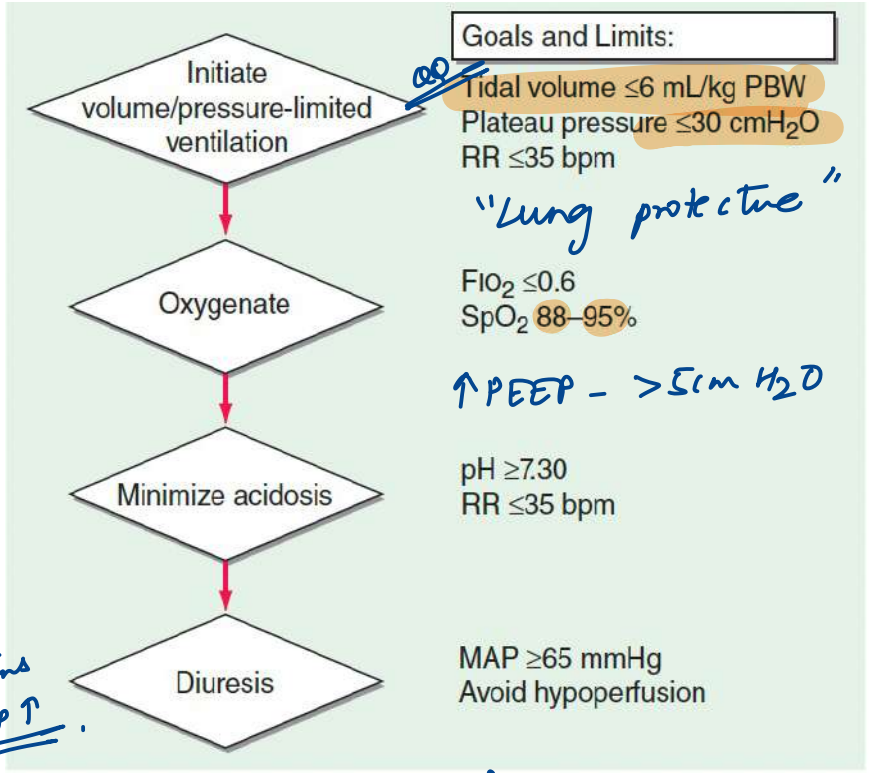
- pCO_2 ↑
- paO_2 ↓ / N

TYPE 3:
PERI-OPERATIVE

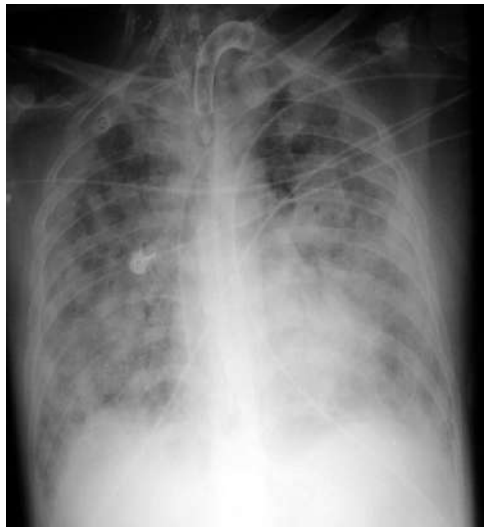
TYPE 4
SHOCK WITH HYPOPERFUSION

ARDS = non ♡ p.edema = Diffuse alv damage → sepsis / pancreatitis / toxins

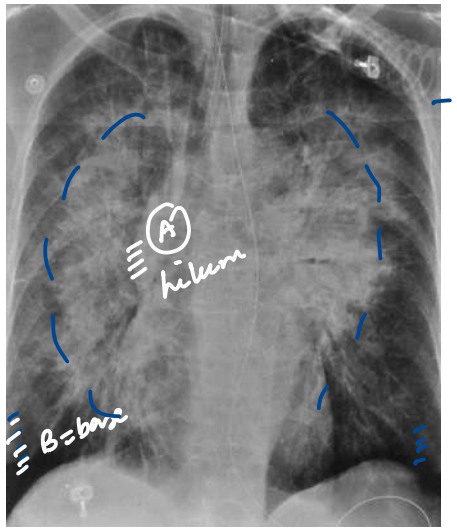
DIAGNOSTIC CITERIA FOR ARDS (Mod. Berlin)			
OXYGENATION PA02/ FI02 <300	**ONSET**	**CHEST RADIOGRAPH**	**ABSENCE E OF LEFT ARTRIAL HYPERTENSION**
Mild: 200-300 Moderate: 100-200 Severe: <100	Acute: within 1 week of clinical insult or new or worsening respiratory symptoms	Bilateral opacities consistent with pulmonary edema not fully explain by effusions, lobar/lung collapse or nodules	↓ PCWP (N) (Swan Ganz Catheter)



ARDS - diffuse b/L opacities



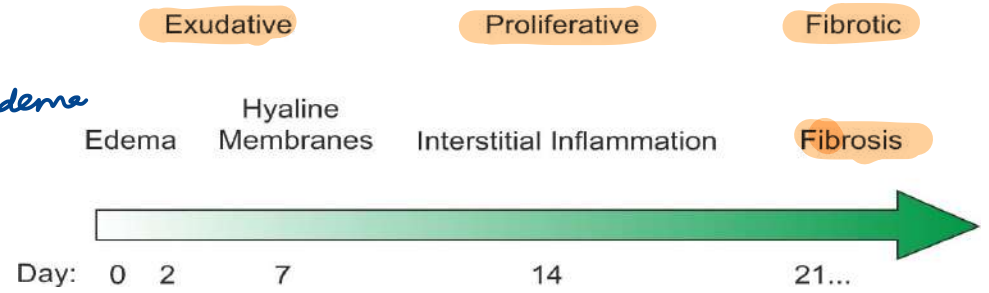
♡ p.edema



LA ↑ LV — p.veins PCWP ↑

- Cephalisation
- ↓
- Kerley A/B lines = interstitial edema
- ↓
- alveolar edema
- "Batwing sign"

PRONE VENTILATION ↑ alv recruitment



PLEURAL EFFUSION

Light's criteria for pleural effusions		
	Transudate	**Exudate**
Protein (pleural/ serum	≤ 0.5	>0.5
LDH (Pleural/serum)	≤0.6	>0.6
	Pleural LDH ≤two-thirds upper limit of normal serum LDH	Pleural LDH> two-thirds upper limit of normal serum LDH
Causes	→ Hydrostatic press ↑ / oncotic press ↓ / lymphatic clearance ↓ → · CHF · NS / cirrhosis / prtn losing enteropathy · Myxedema · PE	Pneumonia / TB / malignancy / RA / PE

Low glucose: 'REM' / empyema / malignancy / RA

High Amylase:
- pancreatitis
- esophageal rupture

Indications of drainage of effusion:
Empyema → pH < 7.2 → GS/ culture (+) → glc ↓ → loculated

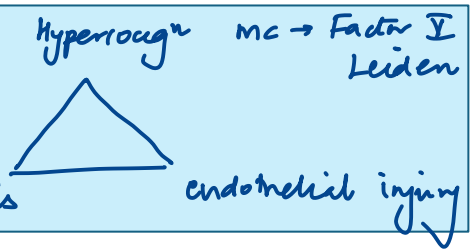
→ CHYLOTHORAX
· Tg > 110 mg/dl – Thoracic duct injury
"Pseudo-chylo" → RA

→ split pleura sign

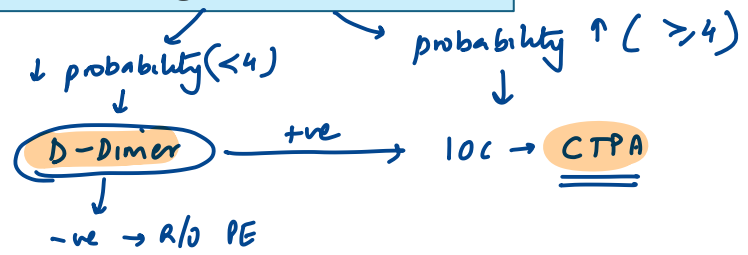
Pigtail

Pulmonary embolism

Virchow triad:

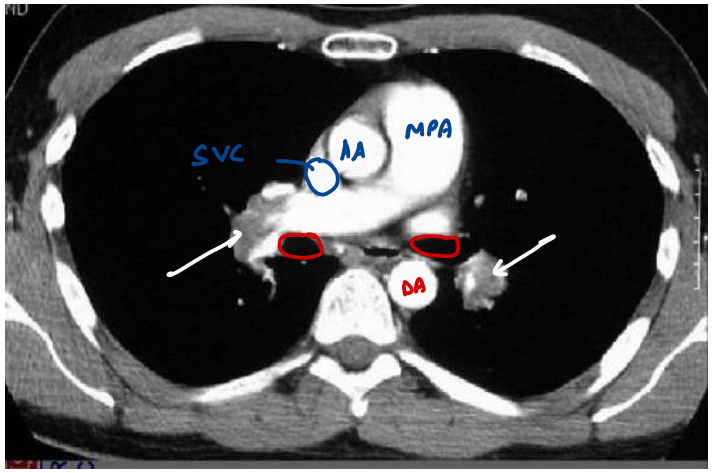


Diagnostic algorithm:



Mod. Well's Score

Clinical Variable	PE Score
C/F of DVT	3.0
Alternative diagnosis less likely than PE	3.0
Heart rate >100/min	1.5
Immobilization >3d; surgery within 4wks	1.5
Prior PE or DVT	1.5
Hemoptysis	1.0
Cancer	1.0



IOC - CTPA

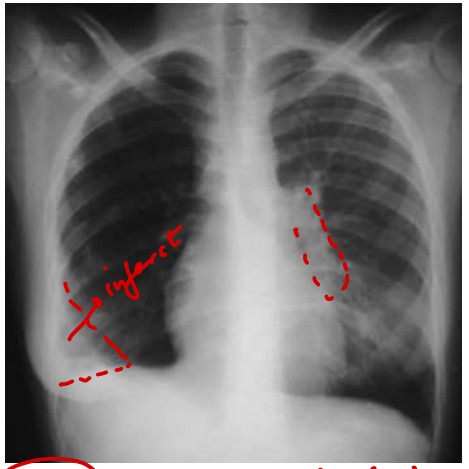
V/Q scan:

iodinated contrast CI / pregnancy
anaphylaxis
CKD

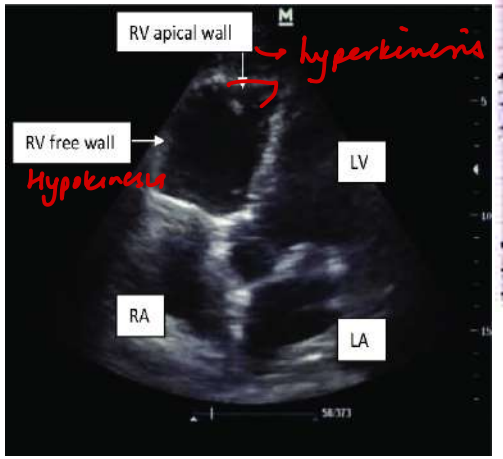
Treatment algorithm:

- Stable → LMWH (anticoagn)
- unstable → Fibrinolytic
  - ↓ anticoagn CI → IVC filter
  - Sx / Endovasc embolectomy

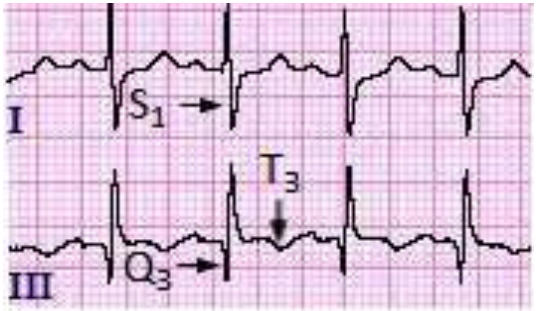
Infrarenal IVC



CxR - Pleural effusion (mc)
- Westermark - oligemia
- Palla's - PA
- Hampton's hump



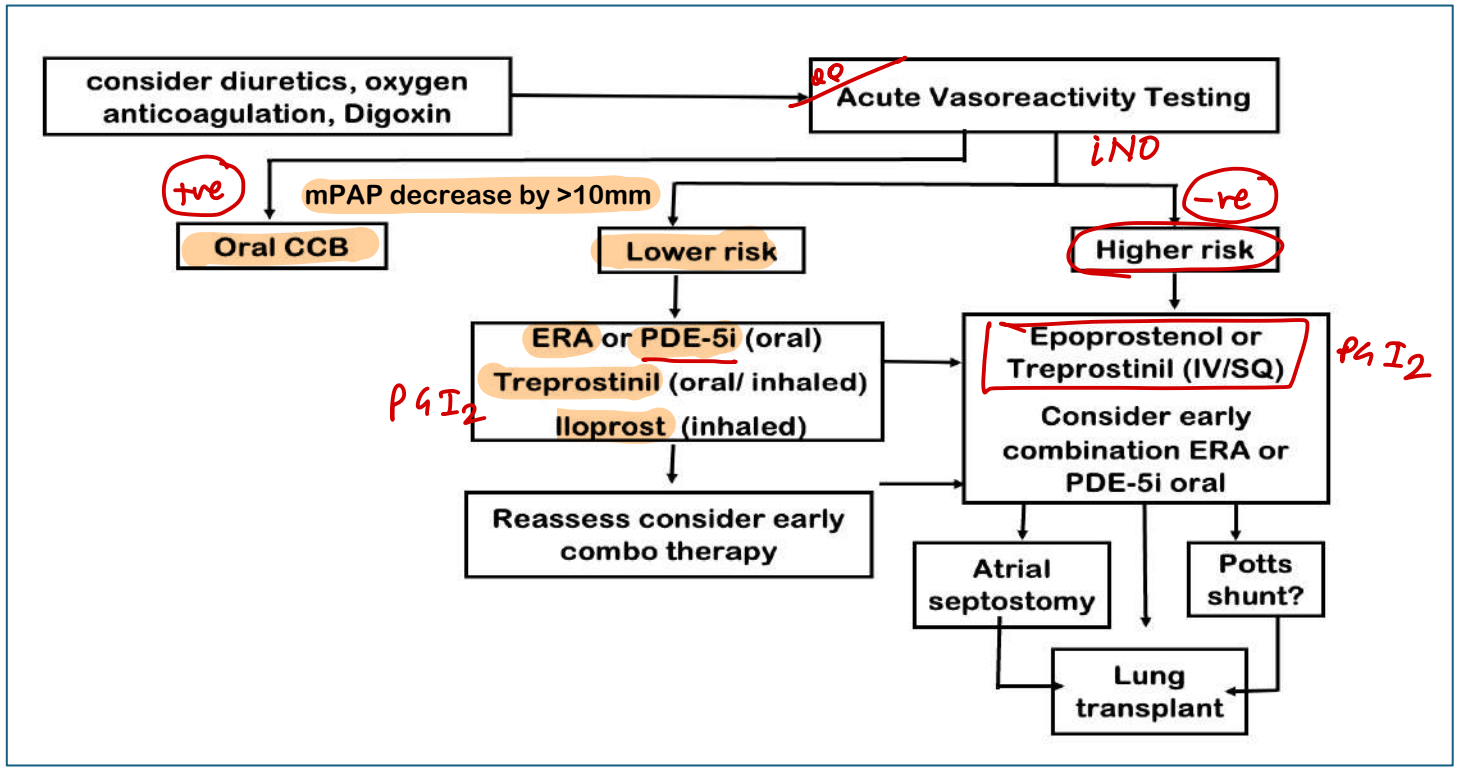
Massive PE → RV strain
McConnell's sign



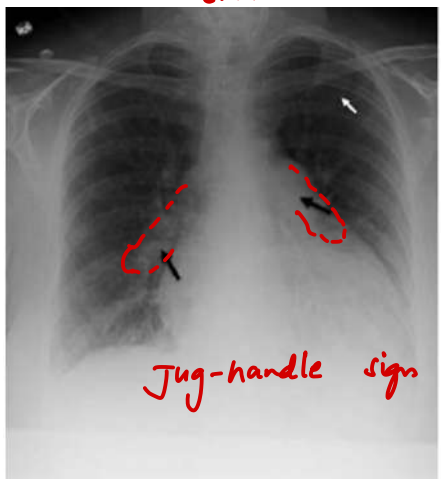
ECG - Specific SI & III TIII (RV strain)
- MC - Sinus tachyc

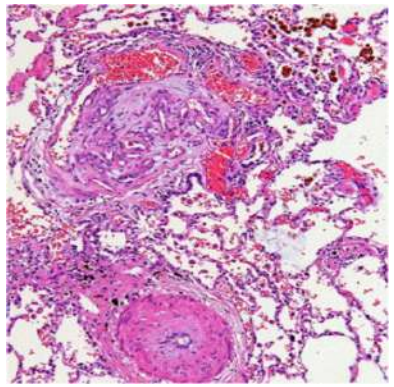
PAH

	DEFINITION: ≥25mm Hg at rest mPAP
GROUP	DANA-POINT CLASSIFICATION
1.	Idiopathic/ Hereditary: BMPR2 Associated with CREST/ HIV / Portal Hypertension/ Schistosomiasis/Eisenmenger
2.	Left heart disease (Post capillary)
3.	PAH owing to lung disease/ hypoxia PVR ↑↑
4.	Chronic thromboembolic pulmonary hypertension
5.	Sarcoid/ Glycogen storage D



CXR



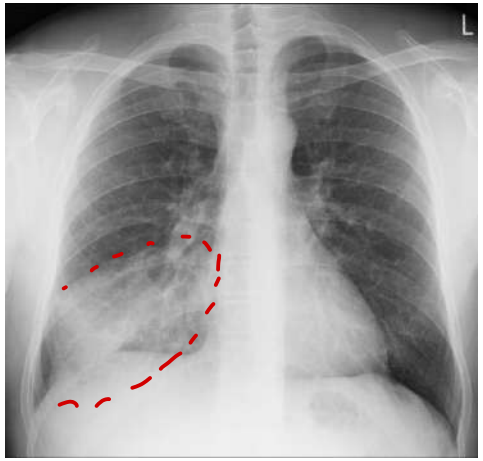


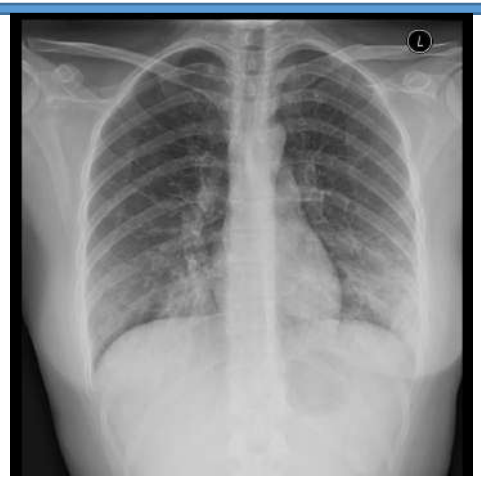
Plexiform arteriopathy

ERA: Bosentan, Macitentan, Ambrisentan
s/e: Hepatotoxicity
PDE5i-: Sildenafil, Tadalafil (↑cGMP)
Guanylate cyclase +: Riociguat
Beraprost PGI_2 (oral)
Selexipag Prostacyclin agonist (oral)

Chest infections

MCC of typical CAP: Lobar consolidation – S.pneumoniae
MCC of atypical CAP: Mycoplasma
MCC of HAP (>48hrs of admission): E.coli / Klebsiella
MCC of VAP (>48hrs of ventilation): emerging - Acinetobacter
early → S.pneumoniae Late – Pseudomonas





"infiltrates" → "atypical"

"typical" "lobar"

CURB-65 Scoring → CRB-65	
Confusion	1
Urea: BUN>19 mg/dL (>7 mmol/L)	1
Respiratory rate>30 breaths /min	1
Systolic BP <90 mm Hg or diastolic BP <60 mm Hg	1
Age> 65 years	1

OP: 0-1	~~β~~ Amoxicillin +/- Macrolides / Doxycycline
IP: 2	FQ / BL+ Azithral/Doxy
ICU: 3-5	BL+ FQ/ Azithral

Congestn (1-2d) → Red hepatisn (3-4d) → Gray hepatisn (5-7d) & Resolution ≥8d.

Aspiration:
- Supine position RLL (sup) / RUL (post)
- Lying on right side or prone RUL
- Upright position RLL

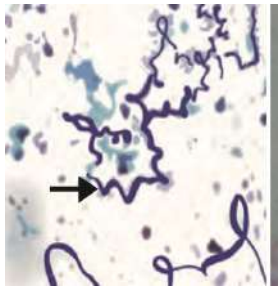
Asthma

- Airway hyper-responsiveness
- Variability-Diurnal PEFR >20%
- Reversibility-Bronchodilator: ↑ >12% / >200ml
- Methacholine: ↓ >20%
- Exercise: ↓ >15% variability

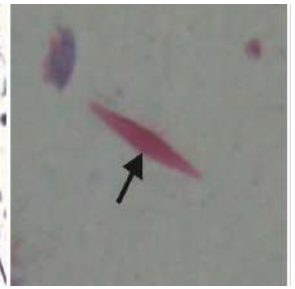
GINA

Step1,2: Symptoms <5d/week:
LD-ICS-Formoterol as needed
Step 3: Most days/ >1/week nighttime:
LD-ICS-Formoterol MART
Step 4: Low lung function:
MD-ICS-Formoterol
Step 5: Add LAMA + HD-ICS + Anti-IgE/IL5

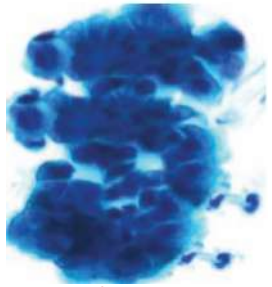
"MART" maintainence & reliever therapy



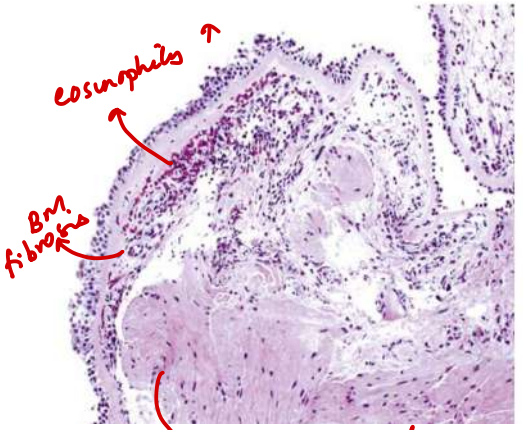
Curschmann spirals



Charcot – Leiden (galectin-10)



Creola bodies



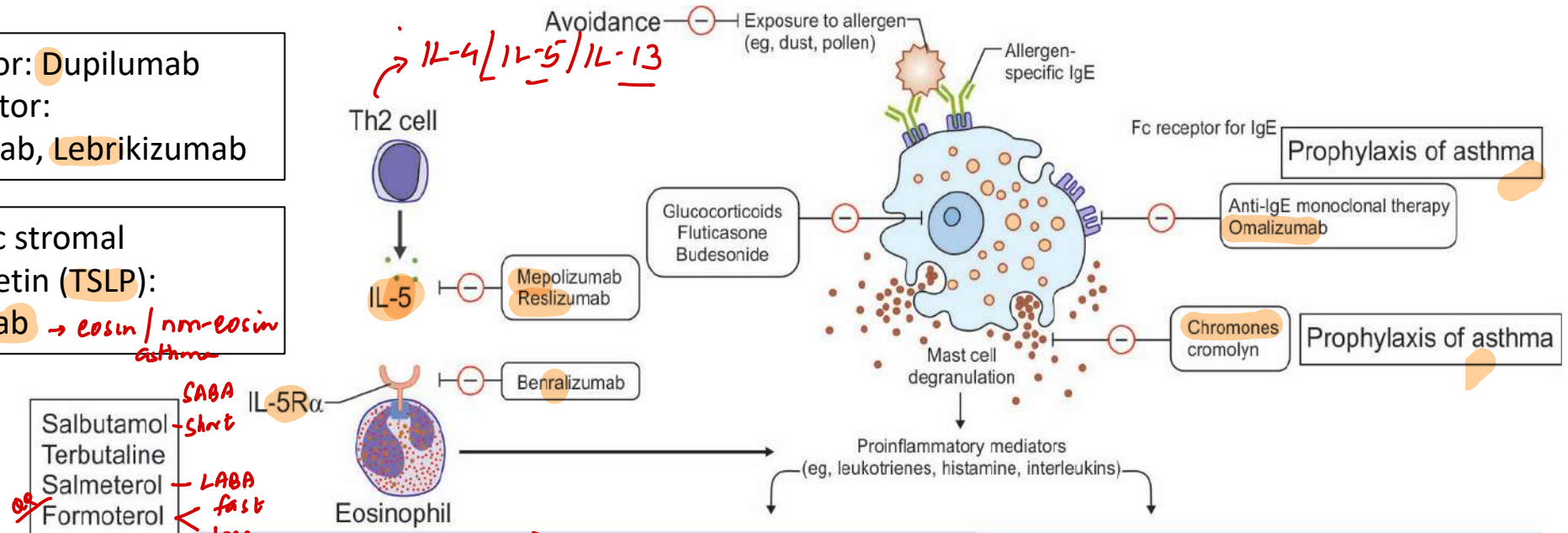
Wheeze-polyphonic

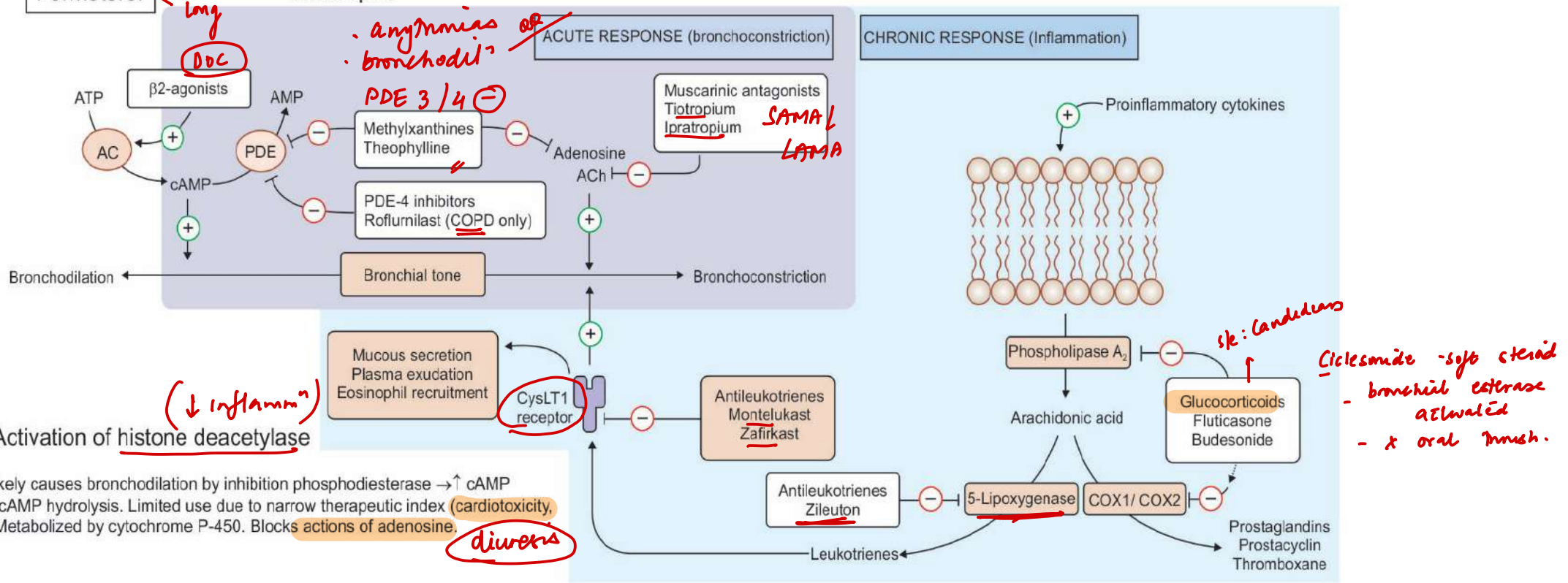
Rx of exacerbation of asthma
1. O2 (>94%)
2. Bronchodilatation: SABA ± SAMA
3. Corticosteroids (Systemic)
4. Adjuvant Therapy-IV Magnesium sulfate 1–2 g

Severe Asthma
PEFR ≤ 50%
Pulsus paradoxus
Unable to speak / complete sentences in one breath
Signs of Impending Respiratory Arrest – PPV
Silent chest
Bradycardia / hypotension/ Altered sensorium
Cyanosis
$PaCO_2$ >42mm

IL-4 inhibitor: Dupilumab
IL-13 inhibitor:
Tralokinumab, Lebrikizumab

Anti-thymic stromal lymphopoietin (TSLP):
Tezepelumab → eosin / non-eosin asthma





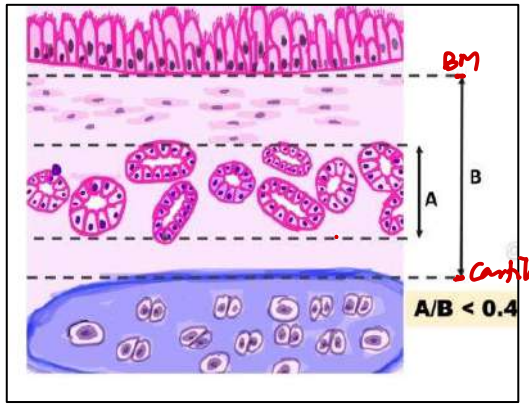
Theophylline–likely causes bronchodilation by inhibition phosphodiesterase →↑ cAMP levels due to ↓ cAMP hydrolysis. Limited use due to narrow therapeutic index (cardiotoxicity, neurotoxicity); Metabolized by cytochrome P-450. Blocks actions of adenosine.

diuresis

Ciclesonide - safe steroid
- bronchial esterase activated
- x oral thrush.

COPD

Chronic bronchitis:
Cough with sputum ≥ 3 months/yr for ≥ 2 years
Type 2 RF (↑capnia)
Hypoxic Pulmonary VC-> PAH – cor pulmonale
BLUE BLOATERS
Reid index: ≥ 0.4 – COPD



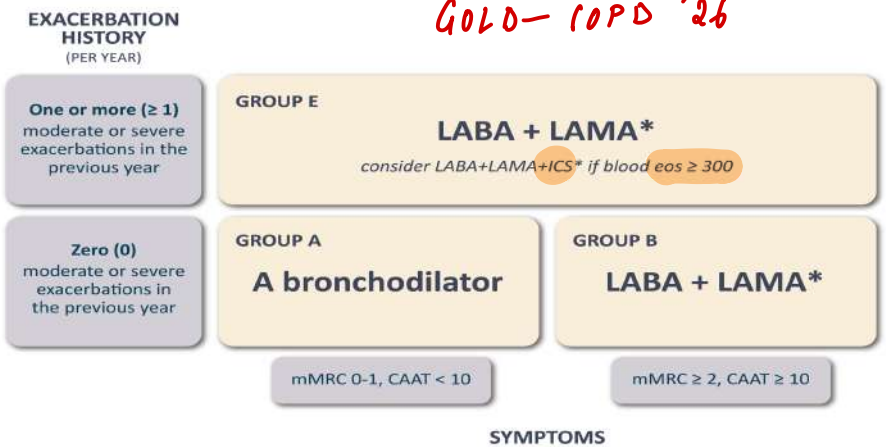
$FEV_1 / FVC < 0.7$ 30+50=80
GOLD 1 – Mild
- $FEV_1 \geq 80\%$ predicted

GOLD 2 – Moderate
- $50\% \leq FEV_1 < 80\%$ predicted

GOLD 3 – Severe
- $30\% \leq FEV_1 < 50\%$ predicted

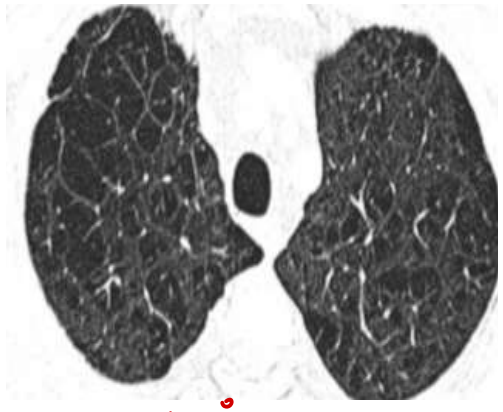
GOLD 4 – Very Severe
- $FEV_1 < 30\%$ predicted

GOLD – COPD '26

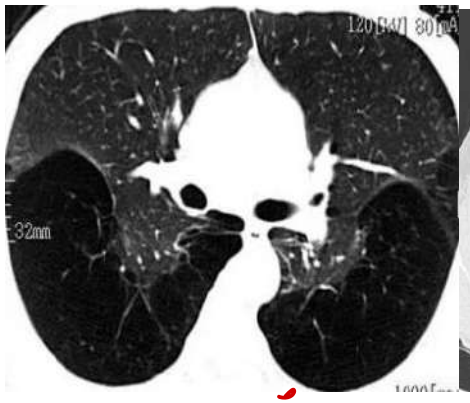


Emphysema
PINK puffers
Type 1 RF ab

alveolar barrier ↓↓
Hypoxemia



centriacinar
- smokers
- UL ↑



pan-acinar
- α_1 AT deficiency
- LL ↑
- cirrhosis

septal (Bullae)
- smokers
- UL ↑
- 1° spnt Ptx

Management of COPD: GOLD 25
↓ mortality
- Smoking cessation
- Long-term O2 - $PaO_2 \leq 55$ mmHg or $SpO_2 \leq 88\%$
- Acute Exacerbation: MCC: Infx → H. influenzae
- O2 + Antibiotics – Azithral DOC
- SAMA +/- SABA
- Steroids only for severe

Modified MRC (mMRC) Dyspnea Scale

mMRC Grade 0-breathless with strenuous exercise

mMRC Grade 1-when hurrying on level ground or walking up a slight hill

mMRC Grade 2

•I walk slower than people of the same age on level ground because of breathlessness

•I have to stop for breath when walking at my own pace on level ground

mMRC Grade 3

•I stop for breath after walking about 100 meters or after a few minutes on level ground

mMRC Grade 4

•I am too breathless to leave the house

I am breathless when dressing or undressing

5 A's Strategy for Smoking Cessation

ASK

ADVISE

ASSESS

ASSIST

ARRANGE -F/U

BODE Index (Prognosis in COPD)

B – **BMI** ≤ 21

O – **Obstruction**-FEV_1 < 50% predicted

D – **Dyspnea**-mMRC ≥ 2

E – **Exercise capacity** 6-minute walk distance < 350m

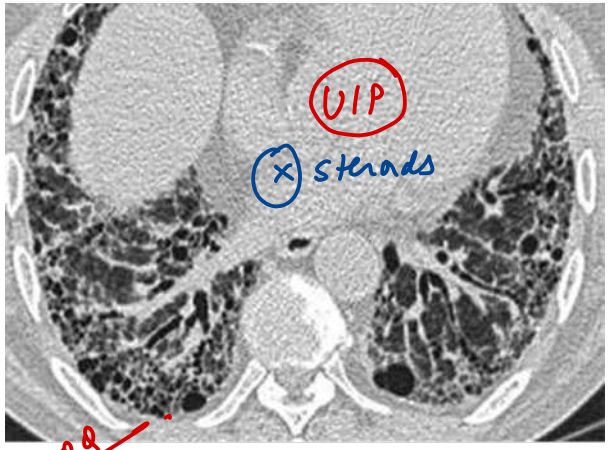
ILD

IOC → HRCT

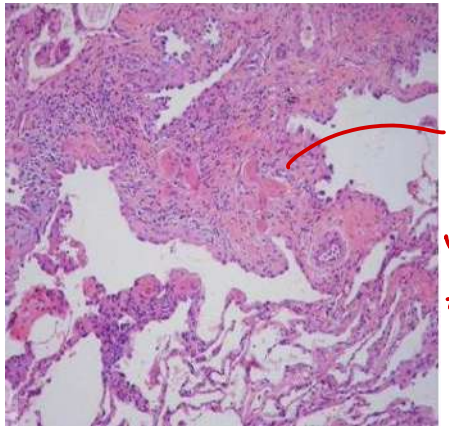
Chronic Fibrosing
- Idiopathic pulmonary fibrosis (IPF) = UIP
- Non-specific interstitial pneumonia (NSIP) – GGO ↑↑ ↘ steroids

ii. Smoking-Related
- Desquamative interstitial pneumonia (DIP)
- Respiratory bronchiolitis–associated ILD (RB-ILD)
- Pulmonary Langerhans cell histiocytosis – smokers, cysts ++

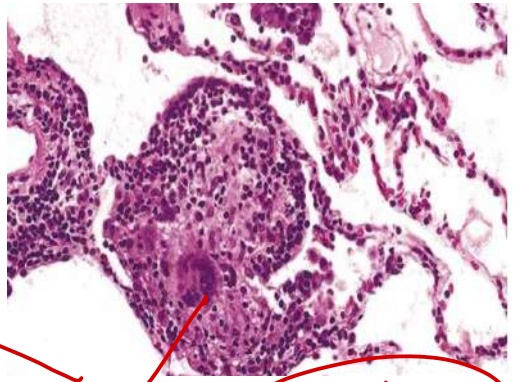
iv. Others
- Lymphangioleiomyomatosis (LAM) → cyst, young ♀ / TSC
- Cryptogenic organizing pneumonia (COP)
- Hypersensitivity pneumonitis qq → Masson bodies
  - MC: Farmer's lung → Thermophilic Actinomyces
  - ↳ type IV > III hyp



qq Honeycombing + traction bronchiectasis
LL ↑



GGO + centrilobular nodules
"mosaic attenuation"



Upper Zone Predominance
- Sarcoidosis
- Silicosis, CWP
- Centrilobular emphysema
- Langerhans cell histiocytosis
- Hypersensitivity pneumonitis

Lower Zone Predominance
- Panlobular emphysema
- UIP
- Asbestosis "base"
- Pulmonary edema

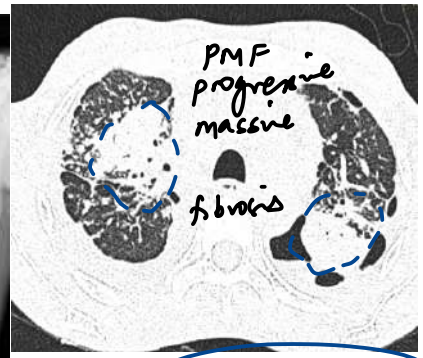
qq
Pirfenidone: anti-TGF-β
Nintendanib: anti-PDGF

OCCUPATIONAL LUNG DISEASES

egg shell Ca 2+

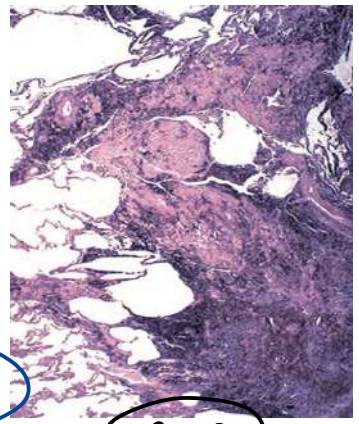
LN — post Rx lymphoma

silicosis sarcoidosis



Silicosis

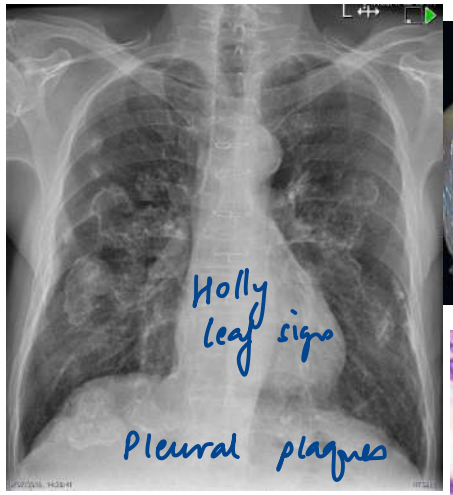
Sand blasting / mining / Quarry



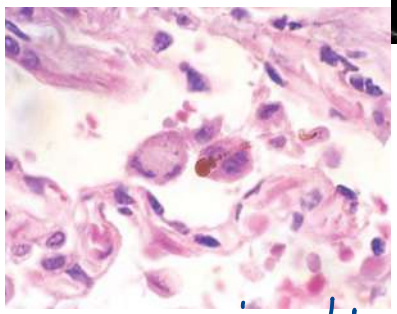
CWP

Caplan syndrome
RA + CWP

Erasmus syndrome
SSc + CWP



Asbestosis → shipyard / electrical insuln



Ferruginous / dumbell

"FROZEN HEMI-THORAX"

most { specific → Mesothelin
common – adenoca

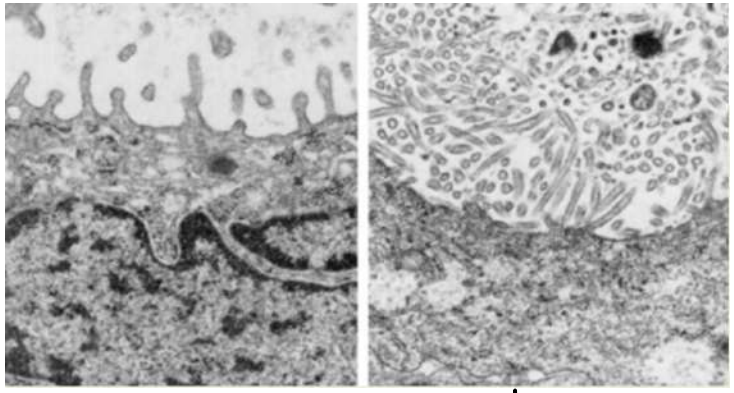
Serpentine/ Crysolite ☺
Amphibole/ Crocidolite ☹

Berrilyosis

Jewellery /dental alloy
Granulomatosis (mimics sarcadosis)
BeLPT

Cobalt

Diamond industry
Giant cell interstitial pneumonitis



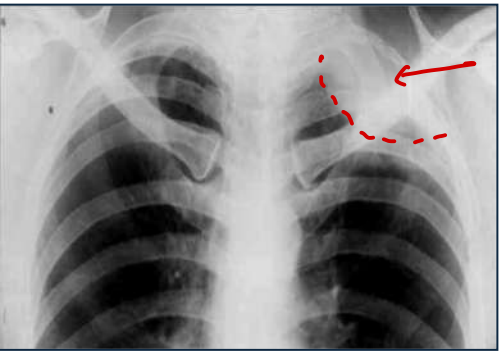
E/M Short villi adca Long Islender mesothelioma

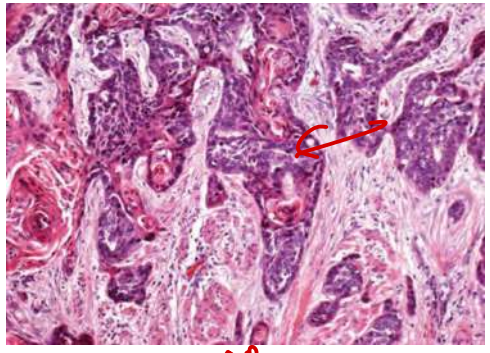
IHC TTF1 / Napsin A Calretinin / CK 5/6 +

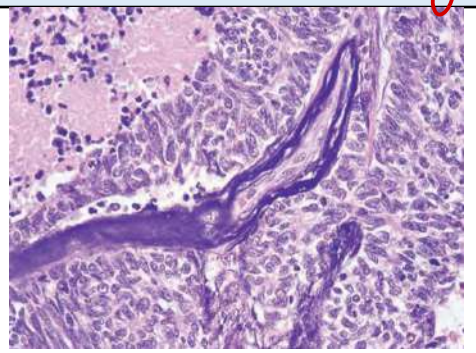
CARCINOMA LUNG

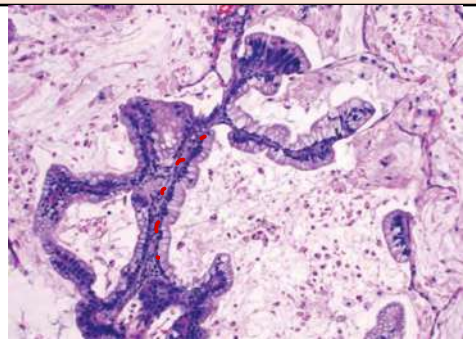
IOC → CECT

	Squamous cell ca	Small cell ca (NE cells)	Adenoca (mc)	Large cell ca
Smoker?	✓	✓	non smokers / ♀	
Location?	central	central	peripheral	
GENES	p53	L-myc	KRAS / EGFR / ALK	
H/P	keratin pearls	Azzopardi effect / salt-pepper	Lepidic spread	(-)
IHC	p40 / p63	synaptophysin / chromogranin / NSE / Bombensin / INSM	TTF 1 / Napsin A	
Paraneoplastic	PTHrp → ↑Ca2+	SIADH / Cushing / LEMS / cerebellar degener	HPOA / Trosseau Sx / NBTE	gynecomastia









PANCOAST TUMOR → IOC: MRI
↳ Brachial plexus / symp plexus

Stage	Criteria
T1	Tumor ≤ 3 cm, surrounded by lung/visceral pleura or located in lobar/peripheral bronchus
T2	Tumor 3-5cm OR invasion of main bronchus (not carina) OR visceral pleura invasion OR crossing fissure into adjacent lobe
T3	Tumor 5-7cm OR invasion of parietal pleura, chest wall, pericardium, phrenic nerve, azygos vein, thoracic nerve roots (T1–T2), stellate ganglion
	Separate tumor nodules in same lobe
T4	Tumor >7 cm OR invasion of mediastinum, thymus, trachea, carina, recurrent laryngeal nerve, vagus nerve, esophagus, diaphragm
	Invasion of heart, great vessels, intrapericardial pulmonary arteries/veins, supra-aortic arteries, brachiocephalic veins, subclavian vessels, vertebral body, lamina, spinal canal, cervical nerve roots, brachial plexus
	Separate tumor nodules in different ipsilateral lobe

Stage	Criteria
N1	Metastasis in ipsilateral peribronchial and/or ipsilateral hilar nodes and intrapulmonary nodes, including direct extension
N2	Metastasis in ipsilateral mediastinal or subcarinal nodes
N3	Metastasis in contralateral mediastinal/hilar nodes OR ipsilateral/contralateral scalene or supraclavicular nodes

M1a	Pleural or pericardial nodules OR malignant pleural/pericardial effusion OR separate tumor nodule(s) in contralateral lobe

Miscellaneous

Screening : Low-dose CT
Age 50-80 years
≥ 20 pack years

Haemoptysis
Massive: > 400 ml / day / > 150 ml 1 sitting
MCC: Bronchial artery - mild: smoking / severe : TB
1st step: O_2 + put bad lung down
Unstable: Rigid bronchoscopy
Diagnostic approach:

CXR → CECT → BAE bronchial A embolism

Antitussive

First-Generation H_1 Antihistamines ↑ sedative

Diphenhydramine, Dimenhydrinate, Chlorpheniramine, Doxylamine

Second-Generation H_1 Antihistamines

Loratadine, Fexofenadine, Desloratadine, Cetirizine

Dextromethorphan

Antagonizes NMDA glutamate/ Synthetic codeine analogue
May cause serotonin syndrome

Mucolytic

N-acetyl cysteine, ambroxol/ bromhexine

never combine antitussive + mucolytic