

** RF when ($P_{aO_2} < 60 \text{ mmHg}$) or ($O_2 \text{ sat} < 88\%$), 2 Types :-

① Type 1 \Rightarrow Hypoxic RF \sim no hypercapnia

② Type 2 \Rightarrow Hypercapnic RF ($P_{aCO_2} > 50 \text{ mmHg}$) \sim Hypoxiemia + Hypercapnia

► Acute RF: - life threatening derangement in $\left\{ \begin{array}{l} \text{Arterial blood gases} \\ \text{Acid-base status} \end{array} \right.$
 - Develops over mins to hrs / pH < 7.3

► Chronic RF: - Develops over several days, allowing renal compensation (pH slightly decrease)
 - polycythemia or cor-pulmonale

≠ Distinction between acute & chronic RF can't on arterial blood gases.

** Normal physiology

- Alveolar $p_{AO_2} = 100\%$, $p_{ACO_2} = 40\%$.

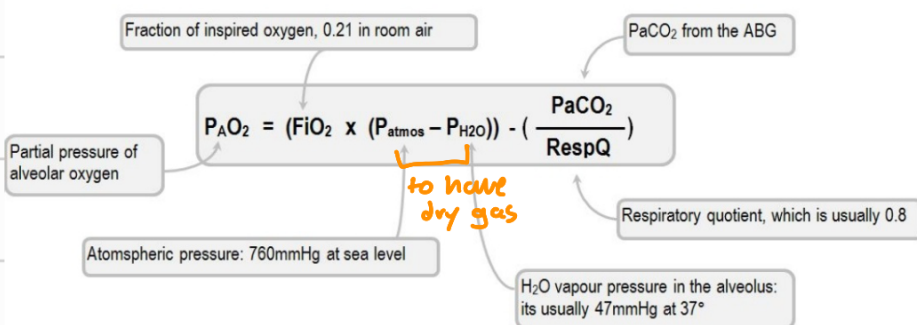
- The [A-a gradient] \rightarrow small difference 5-10 mmHg between $\left\{ \begin{array}{l} \text{Alveolar} \\ \text{Arterial} \end{array} \right.$.

≠ physiologic shunt = 2% \gg normal [A-a gradient] < 10 mmHg

\hookrightarrow Distinguish intrinsic from extrinsic restrictive lung disease.

- P_{ACO_2} inversely proportional to ventilation (\uparrow ventilation \downarrow P_{ACO_2})

P_{AO_2} depends on inhaled O_2 (F_{IO_2}) & P_{ACO_2} :-



RF look at \rightarrow A-a (calculations):

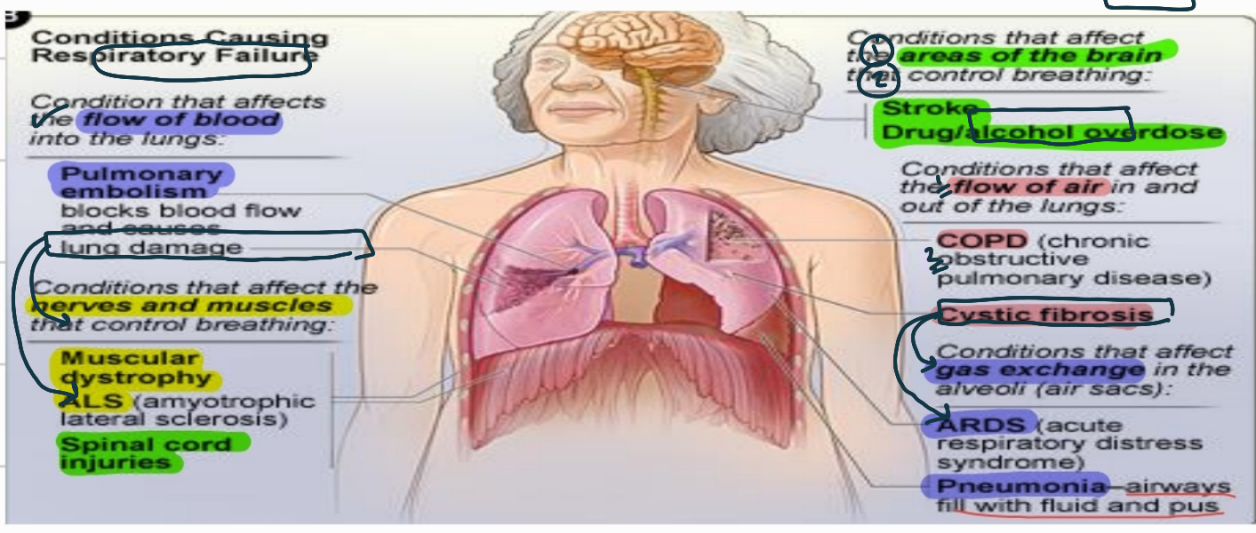
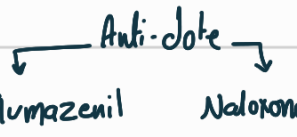
- P_{aO_2} & $P_{aCO_2} \rightarrow$ from ABGs
- $P_{ACO_2} = P_{aCO_2} * 1.25$ or $P_{aCO_2} / 0.8$
- \gg P_{AO_2} dependant on F_{IO_2} & P_{ACO_2}

↳ Medications

affect brain & cause \uparrow \dot{V}_E

① Benzodiazepine

② Opioids



↳ Causes of hypoxemia \Rightarrow

1 Pulmonary shunt

- Normal (Q), poor (V) \rightarrow ratio = 0
- Give O_2 does not correct hypoxemia, except small atelectasis responds.
- Pneumonia / ARDS / collapse
- Atelectasis / cyanotic heart disease

2 V/Q Mismatch

- ▶ normal ratio ≈ 0.8
- ▶ \downarrow ratio (< 0.8) \rightarrow \downarrow ventilation (pneumonia/collapse/atelectasis)
 - * respond to O_2 therapy \rightarrow \uparrow perfusion
 - * extreme decrease = behave as shunt
- ▶ \uparrow ratio (> 0.8) \rightarrow \uparrow ventilation
 - * No respond to O_2 \rightarrow \downarrow perfusion (pulmonary embolism)
 - * extreme increase = behave as dead space

3 Diffusion impaired

- Structural problem $\left\{ \begin{array}{l} \downarrow \text{surface: emphysema} \\ \uparrow \text{Thickness: Fibrosis/Restrictive} \end{array} \right.$
- \uparrow $\frac{A-a}{\text{normal lower}}$ gradient * Respond to O_2

4 High altitude ($\downarrow FiO_2$)

- $\downarrow PAO_2 \Rightarrow \downarrow PaO_2 \Rightarrow$ normal (A-a)

5 Hypoventilation [minute V = \downarrow R.R \times Tidal volume]

- $\downarrow PAO_2$ $\downarrow PaO_2$ $\uparrow PaCO_2 \Rightarrow$ normal (A-a)

- Due to benzodiazepine, opioids, stroke

* Respond

- Acetazolamide prevent & reduce symptoms

(resp. alkalosis) - Suddenly \Rightarrow hyperventilation \oplus \uparrow 2,3-DPG

- Chronically \Rightarrow polycythemia \oplus kidneys $\uparrow H_2CO_3$

* Respond to O_2 therapy

Summary >>

Causes of Hypoxemia			
Cause	PaO ₂	A-a gradient	PaO ₂ response to supplemental oxygen
1 Hypoventilation ↳ PaCO ₂ ↑	Decreased	Normal *	Increases ✓
2 Diffusion Impairment	Decreased	Increased	Increases ✓
3 amount of blood bypassing oxygenation ↳ Shunt	Decreased	Increased	Does not increase. *
4 V/Q Mismatch	Decreased	Increased	Usually increases (depends on V/Q mismatch type) <math>< 10.8</math>
5 High Altitude	Decreased	Normal *	Increases ✓

↳ PaCO₂ normal in all types except hypoventilation.

↳ Normal (A-a gradient) ← hypoventilation
↳ Normal (A-a gradient) ← high altitude

↳ ↑ (A-a gradient) ← Shunt
↳ ↑ (A-a gradient) ← V-Q mismatch
↳ ↑ (A-a gradient) ← Diffusion impairment

↳ Give O₂ enhance
 ↳ Yes → v-Q/impairment
 ↳ No → shunt

↳ ↑ PaCO₂ ⊕ ↑ (A-a) ⇒ hypoventilation with

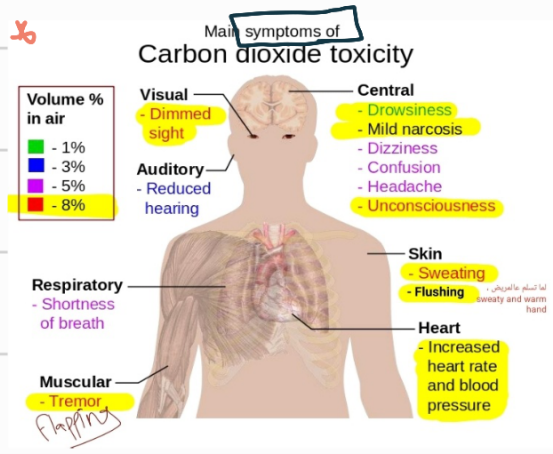
↳ another hypoxic mechanism
 ↳ emphysema with chest trauma
 ↳ Asthma with muscle fatigue

▶ Hypercapnia (PCO₂ > 50 mmHg), normal is 35-45 mmHg

↳ ↓ ventilation ↑ PaCO₂

$$PaCO_2 = \frac{VCO_2}{K / V_A}$$

(CO₂ production constant in our bodies) (constant) (Alveolar ventilation)



↳ Causes of Type 2 RF:

↳ Treatment:

- COPD / Asthma] => hyperinflation
- Drugs (morphine)
- obesity hypoventilation syndrome

- ICU & ABC assessed
- O₂ ← RF1 (95%)
← RF2 (98-92%)
- Treat underlying cause

▶ ARDS

↳ Mechanism of action of ARDS is ⇒ Shunting

ARDS
 Acute Respiratory Distress Syndrome
 within 1 week

- Needs to be acute
- Bilateral pulmonary infiltrate
- Low oxygenation → <math>< 300</math>
- Non-cardiogenic in nature

↳ Most cases associated with

- ① pneumonia (w or w/o sepsis) or
- ② non-pulmonary sepsis

↳ Manifests as → dyspnea
 ↳ Tachy
 ↳ Hypoxemia
 ↳ Evolves into RF

↳ <math>< 300</math> [Normally PaO₂ = 90, FiO₂ = 0.21
 oxygenation ratio = 450 mmHg]

- Severity → Mild: 200 mmHg < PaO₂/FiO₂ ≤ 300
 ↳ Moderate: 100 < ratio ≤ 200
 ↳ Severe: ratio ≤ 100

- Treatment → mechanical ventilation
 ↳ prone position
 ↳ low tidal volume & high PEEP.