

# Respiratory Equations

## Partial Pressure of Gas

- Partial pressure of gas = concentration x total pressure  
Eg dry air had 20.93% O<sub>2</sub>  
@ sea level pressure = 760mmHg ∴ P<sub>o2</sub> @ sea level = 20.93/100 x 760 = 159mmHg
- When air inhaled it is warmed & moistened  
Water vapour pressure = 47mmHg ⇒ total dry gas pressure = 760 - 47 = 713  
∴ P<sub>iO2</sub> inspired air = 20.93/100 x 713 = 149mmHg

## Alveolar Gas Equation

- Allows relationship between fall in P<sub>O2</sub> & rise in P<sub>CO2</sub> which occurs in hypovent can be calculated

$$P_{AO2} = P_{iO2} - \frac{P_{ACO2}}{R} + F$$

- F = small correction factor (~2mmHg)
- R = respiratory quotient (~0.8)  
↳ determined by CO<sub>2</sub> production/O<sub>2</sub> consumption  
↳ ie metabolism of tissues in steady state
- P<sub>iO2</sub> = composition of inspired gas

## Fick Principle

- = application of Law of Conservation of Matter
- uptake (or output) of a substance by a tissue must be equal to difference between amount entering tissue (flow x arterial concentration) and the amount leaving the tissue (flow x venous concentration)
- rearrangement of the formula:

flow = uptake / A - V concentration difference)

$$\text{Blood flow/min} = \frac{\text{O}_2 \text{ consumption/min}}{\text{Conc of O}_2 \text{ in pulmon artery} - \text{Conc O}_2 \text{ in pulmon vein}}$$

Eg cardiac output:

$$\begin{aligned} \text{CO} &= \frac{250\text{mls O}_2/\text{min}}{200\text{mls O}_2 \text{ (art o}_2 \text{ content)} - 150\text{mls O}_2/\text{l (mixed venous o}_2 \text{ content)}} \\ &= 250/50 \\ &= 5 \text{ L/min} \end{aligned}$$

## O<sub>2</sub> flux or Delivery

$$D_{O2} = C_{aO2} \times \text{CO}$$

## Measurement of VQ Mismatch

- In practise use alveolar-arterial P<sub>O2</sub> difference
- Need to calculate predicted P<sub>AO2</sub> & use alveolar gas equation:

$$P_{AO2} = P_{iO2} - \frac{P_{ACO2}}{R} + F$$

- Measured arterial P<sub>CO2</sub> used for P<sub>A</sub>CO<sub>2</sub>
- P<sub>iO2</sub> = inspired alveolar P<sub>O2</sub>

- Then A-a difference = P<sub>AO2</sub> (predicted) - P<sub>aO2</sub> (measured)
- Should be <10

- Eg pt breathing air at sea level has
  - o Inspired P<sub>o2</sub> 149mmHg
  - o a measured P<sub>aO2</sub> of 50mmHg
  - o measured P<sub>aCO2</sub> of 60mmHg



$$\begin{aligned} 149 - \frac{60}{0.8} &= 74 \text{ mmHg predicted PaO}_2 \\ \therefore 74 - 50 &= 24\text{mmHg A-a difference} \\ &\quad \hookrightarrow \text{high } \therefore \text{VO difference} \end{aligned}$$



### Diffusion Capacity of Lung

- Diffusion capacity of lung for CO = Volume of CO transferred (ml/min) / Alveolar Partial pressure of CO (mmHg)

$$D_L = \frac{V_{CO}}{P_{Aco}}$$

### Pulmonary Vascular Resistance

- vascular resistance =  $\frac{\text{input pressure} - \text{output pressure}}{\text{blood flow}}$

### Water Balance in Lungs

$$\text{net fluid out} = (P_c - P_i) - o(\pi_c - \pi_i) \times k$$

$P_c$  = capillary hydrostatic pressure

$P_i$  = interstitial pressure

$O$  = reflection coefficient ie effectiveness of capillary in preventing proteins across it

$\pi_c$  = osmotic force of blood

$\pi_i$  = osmotic force of interstitium

### Hypoventilation

- alveolar ventilation and PCO2 relationship:

$$PCO_2 = \frac{CO_2 \text{ production}}{\text{Alveolar Ventilation}} \times \text{constant}$$

### O2 Saturation

- O2 saturation of Hb = percentage of available binding sites which have O2 attached  
↳ calculated by

$$\frac{\text{O2 combined with Hb}}{\text{O2 capacity}} \times 100$$

### O2 Capacity

- O2 capacity = 20.8ml O2/100ml blood in norm Hb ie 15g/100ml  
↳ ∴ if anaemia of 10g/100ml capacity would be  $20.8 \times 10/15 = 13.9$

### O2 Concentration of Blood

Oxygen concentration of blood: (ml O2/100ml blood)

$$= \frac{(1.39 \times \text{Hb} \times \text{SpO}_2) + 0.003 \text{ PO}_2}{100}$$

$\text{Hb} - \text{gm}/100\text{ml}$   
 $\text{Po}_2 \text{ mmHg}$

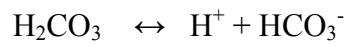
### Bicarbonate

- bicarbonate formed by



## pH

- pH resulting from solution of CO<sub>2</sub> in blood & dissociation of carbonic acid given by Henderson-Hasselbalch equation:



or

$$\text{pH} = \text{pK} + \log \frac{\text{HCO}_3^-}{0.03\text{PCO}_2} \quad \text{pK value} = 6.1$$

- bicarbonate concentration determined by kidney
- PCO<sub>2</sub> by lung