Arterial Blood Gases

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Session Aims and Objectives

- Identify the indications for taking a blood gas
- Identify the components of a blood gas and an awareness of normal values
- Interpret an arterial blood gas and be able to identify acid-base derangements
- To have a working knowledge of compensation and how this applies to clinical practice

Indications for taking an ABG

Patient deterioration

- Increase/decrease respiratory rate
- Increase/decrease in $SP0_2$
- Cardiovascular instability
  - ECG changes - rate, rhythm, ectopic beats
- Change in urine output/kidney function

Monitoring patient condition

What does an ABG measure?

Measurement	Definition	Range
pH	Overall acid-base balance	7.35-7.45
pCO_2	Carbon dioxide concentration in arterial blood	4.5-6.0 kPa
$p0_2$	Oxygen level in arterial blood	10-13.5 kPa
HCO_{3-}	Bicarbonate level	22-26 mmol/l
BE	The metabolic aspect of acid-base balance is reflected in base excess	-2 - +2

What do these numbers mean?

pCO_2

This dissolves in plasma to make an acid. Therefore how much pCO_2 is in the blood alters the bodies pH

This is the respiratory component of acid-base balance

pO_2

Oxygenation is important for patients but doesn't impact on acid-base balance

pH

This is a measure of how acidic or alkali the blood is

HCO_3^- (Bicarbonate)

Bicarbonate is an alkali. Therefore, how much bicarbonate is in the blood alters the bodies pH

This is the metabolic component of acid-base balance

Oxygenation

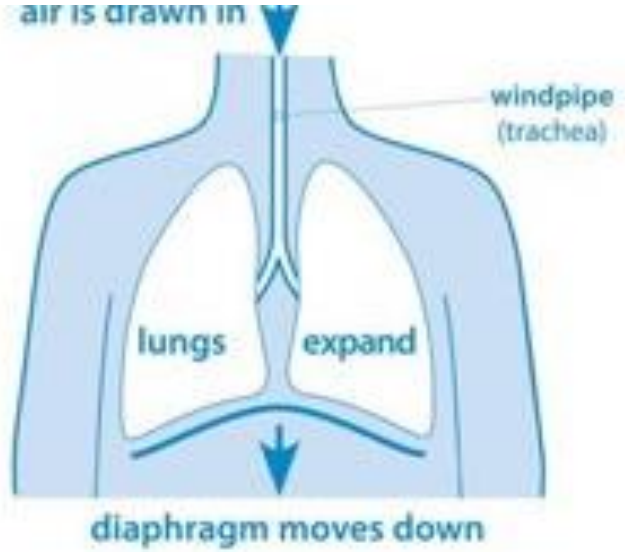
Pulmonary Ventilation

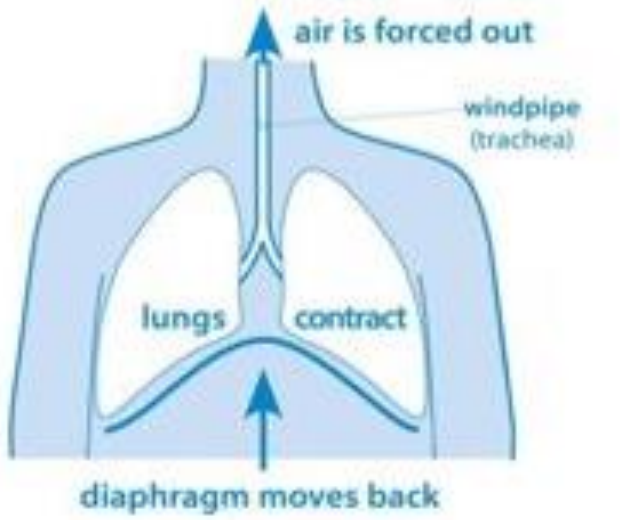
External Respiration

Internal Respiration

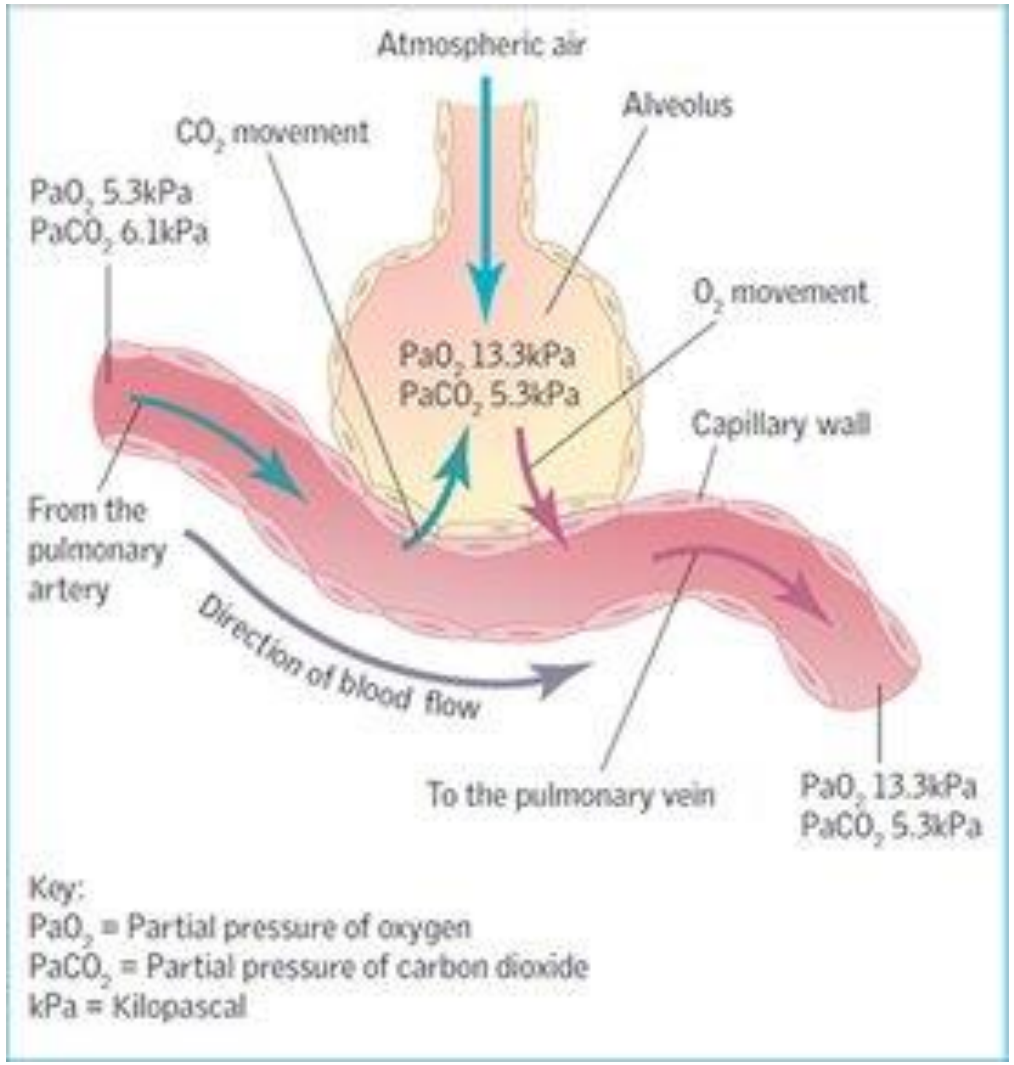
Pulmonary Ventilation

- Respiratory gases go in and out of the lungs due to a pressure gradient
- Boyles Law states that if the volume of a closed container increases, the pressure inside the container reduces and vice versa



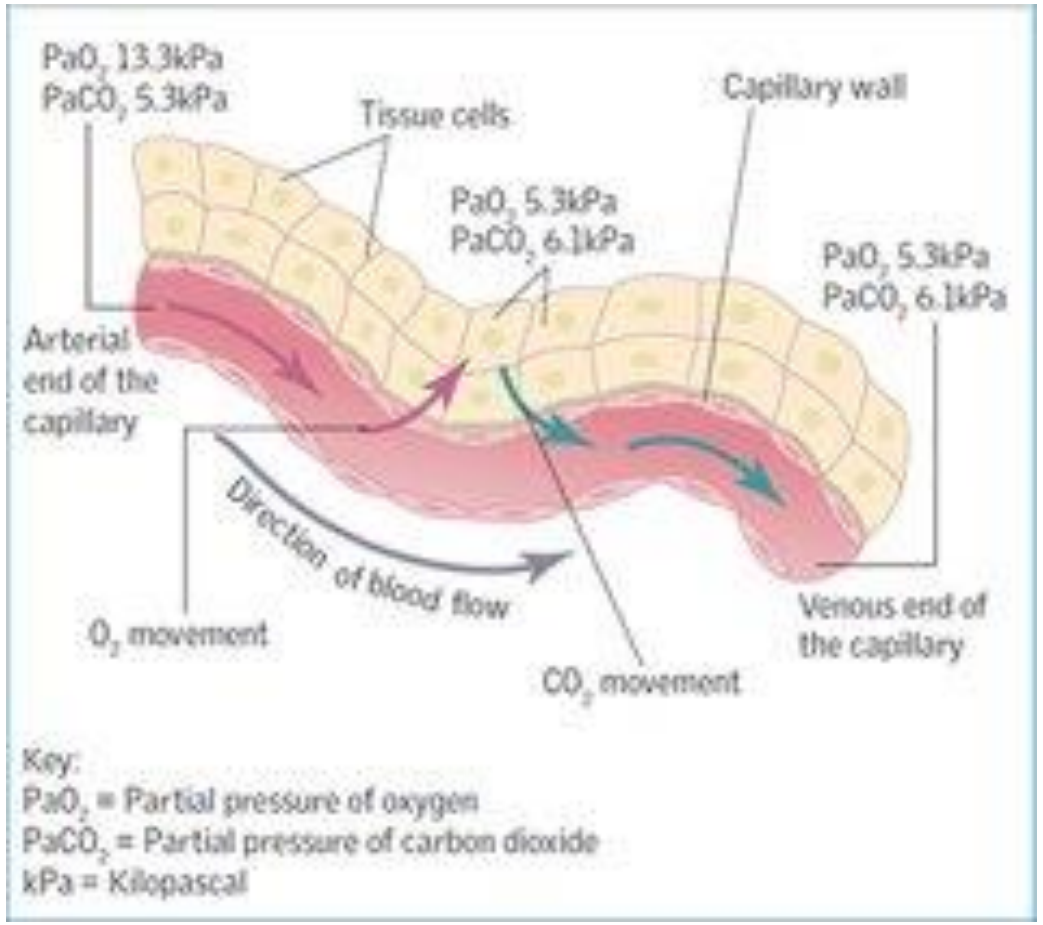


External Respiration



- Respiratory gases move between the alveoli and the blood via diffusion
- There is a concentration gradient between the alveoli and the blood which leads to O_2 diffusing into the blood and CO_2 diffusing into the alveoli

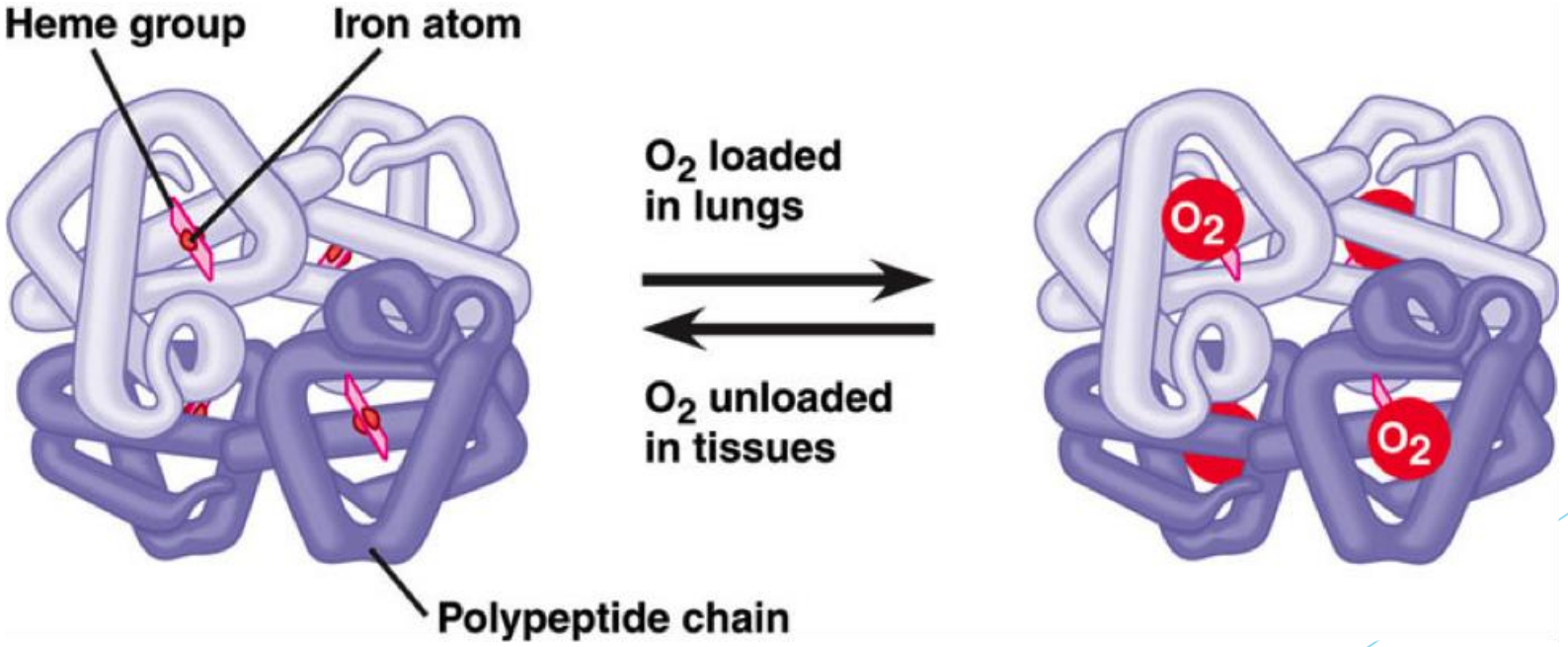
Internal Respiration



- There is an exchange of gases between blood and the cells due to a concentration gradient

Transport of Gases

- Oxygen combines with haem leading to the formation of oxyhaemoglobin
- How much O_2 combines with Hb is determined by pO_2
- Full saturation means that all the Hb has been converted to oxyhaemoglobin



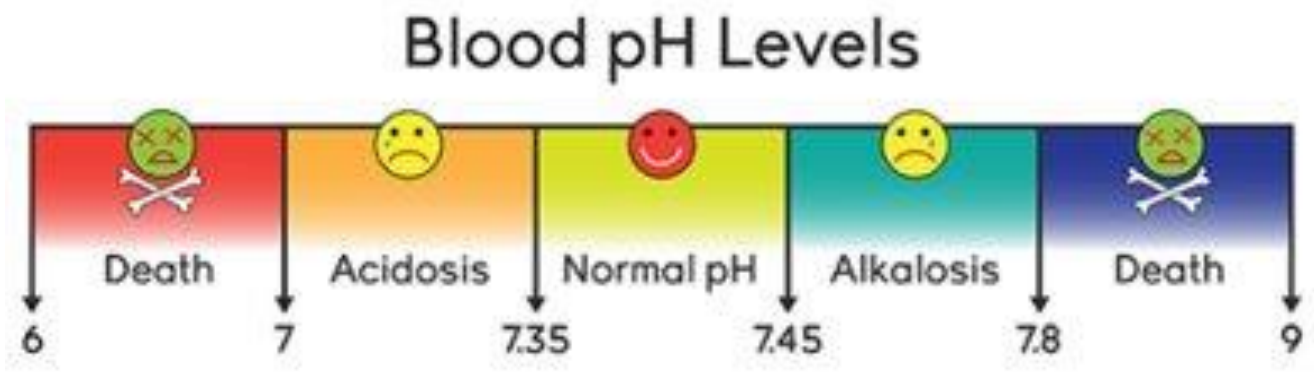
Acidotic or Alkalotic?

Acidosis

Too much pCO_2 or not enough HCO_3^- will make the patient acidotic

Alkalosis

Too much HCO_3^- or not enough pCO_2 will make the patient alkalotic



Respiratory or metabolic?

- Match the pCO_2 or HCO_3^-
- Is the pCO_2 normal? (4.5-6 kPa)
  - Above 6.0 acidotic
  - Below 4.5 alkalotic
- Is the HCO_3^- normal? (23-28 mmoll)
  - Below 23 acidotic
  - Above 28 alkalotic

CO_2 matches = respiratory
HCO^{3-} matches = metabolic

What does the ABG numbers tell us about the patient?

Respiratory Acidosis
- pH will be below 7.35
- pCO_2 will be above 6
- Conditions:
  - Type 2 respiratory failure – COPD, ARDS, pneumonia

Respiratory Alkalosis
- pH will be above 7.45
- pCO_2 will be below 4.5
- Conditions:
  - Hyperventilation

Metabolic Acidosis
- pH will be below 7.35
- Bicarbonate will be below 22
- Conditions:
  - Renal failure, ischaemia causing lactic acidosis

Metabolic Alkalosis
- pH will be below 7.45
- Bicarbonate will be above 26
- Conditions:
  - Vomiting, diarrhoea, loss of gastric fluid

Control of hydrogen ion concentration (pH)

- The body will always try to maintain normal pH
  - If pH becomes too acidic the body will try and compensate by making more alkali
  - If pH becomes too alkaline the body will try and compensate by making more acid

This process is known as compensation

Compensation

Is the CO_2 or HCO_3^- acidotic or alkaolitic as you expect according to the pH?

If the CO_2 or HCO_3 are not what you would expect then there is compensation in the system.

Example:

- The pH is acidotic, CO_2 is acidotic and the HCO_3 is alkalotic
- If the CO_2 matches the pH then the primary problem is respiratory acidosis and the HCO_3 is evidence of metabolic compensation.

Control of Hydrogen Ion Concentration

- The body controls hydrogen ion concentration (pH) in three main ways

The acid-base buffer system combines with hydrogen ions to avoid excessive changes in pH. This is an **immediate** action

The respiratory centre regulates removal of CO_2 from extracelluar fluid. It acts in a **few minutes** to eliminate CO_2

The kidneys can excrete acid or alkaline urine which will influence hydrogen ion concentration. The renal response is **relatively slow** but the most powerful

Buffering of Hydrogen Ions

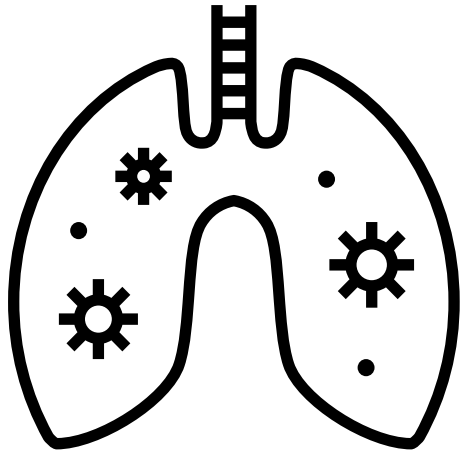
- A buffer is a substance that can reversibly bind hydrogen ions
- When hydrogen ion concentration increases the ions get bound to an available buffer.
- When hydrogen ion concentration decreases, hydrogen ions are released from the buffer
- The bicarbonate buffering system is the most important

$$CO_2 + H_2O \rightleftharpoons H_2CO_3$$

$$CO_2 + H_2O \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

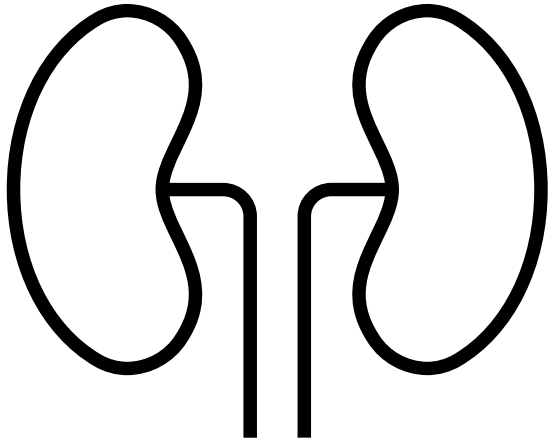
Respiratory regulation of acid-base balance

- Acid-base is also controlled by regulating extracellular CO_2
- An increase in ventilation (↑TV, ↑RR) will lead to an increase in CO_2 elimination
- The pH of extracellular fluid can alter the rate of ventilation



Renal control of acid-base balance

- There are three mechanisms involved in this process
  - Primary active secretion of hydrogen ions
  - Secondary secretion of hydrogen ions
  - Reabsorption of filtered bicarbonate ions and production of new bicarbonate ions



Are the pO_2 & the O_2 saturation normal?

Is the pH normal?

Is the CO_2 normal?

Is the HCO_3^- normal?

Match the CO_2 or the HCO_3^- with the pH

Does the CO_2 or the HCO_3^- go in the opposite direction to what you expect?

6 Stages to ABG Analysis