Arterial Blood Gases

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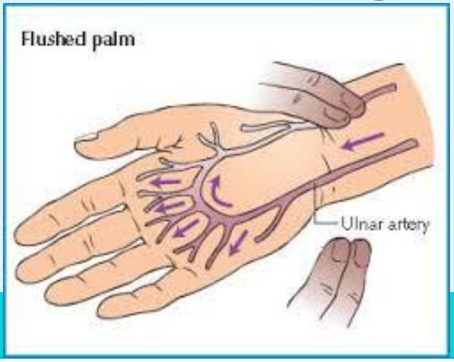
What useful information can we get from an ABG?

- Partial pressures of oxygen and carbon dioxide
- Acidity of the blood
- Bicarbonate levels and base excess
- Haemoglobin
- Electrolytes
- Lactate
- Glucose

How do we obtain the samples?

- Either direct stab
- From arterial line
  - When taking use specific heparinised gas syringe
- Eliminate bubbles from the sample

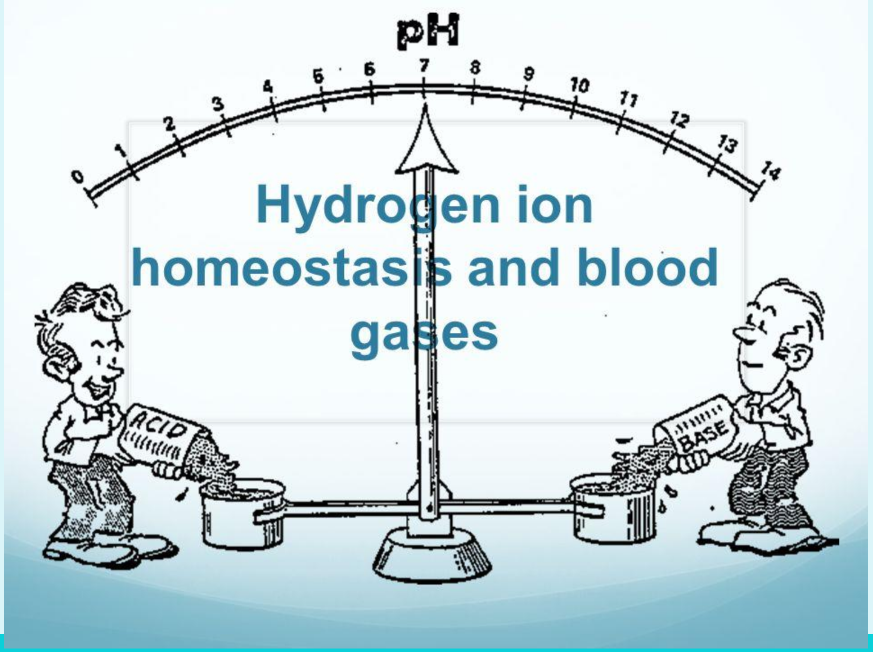
- Note, can use venous gas if not requiring oxygenation etc



Physiology

- Body depends on having strict control of acids/alkalis to enable cellular processes to function normally

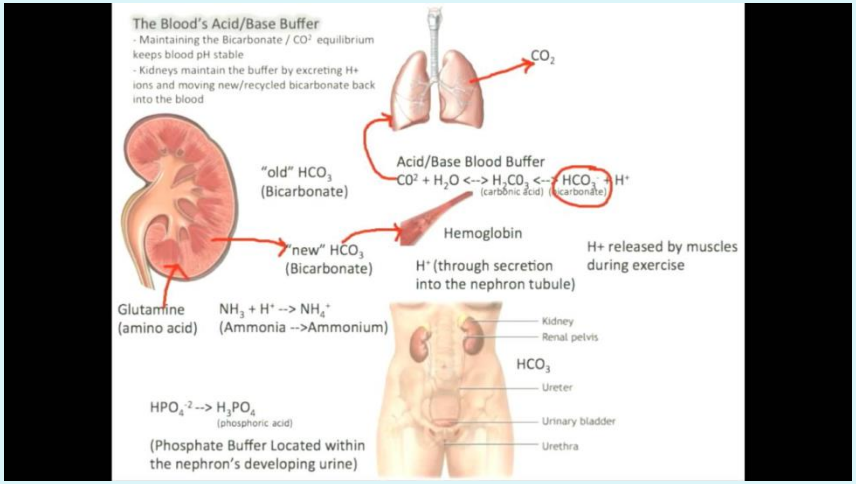
- Buffers = solutions that minimise changes in [Hydrogen ion]

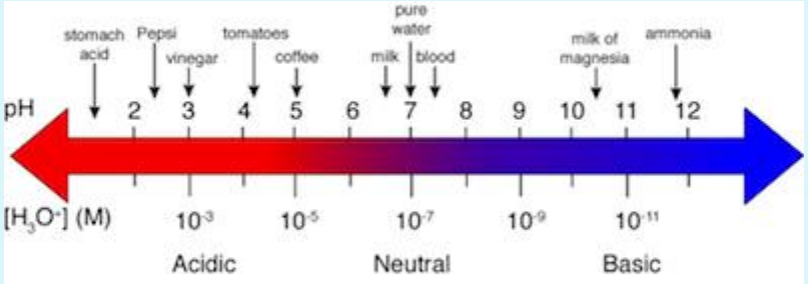


Physiology continued

- Buffers;
  - Bicarbonate – HCO3
  - Haemoglobin
  - Plasma Proteins
  - Phosphate
  - Calcium bicarbonate in bones

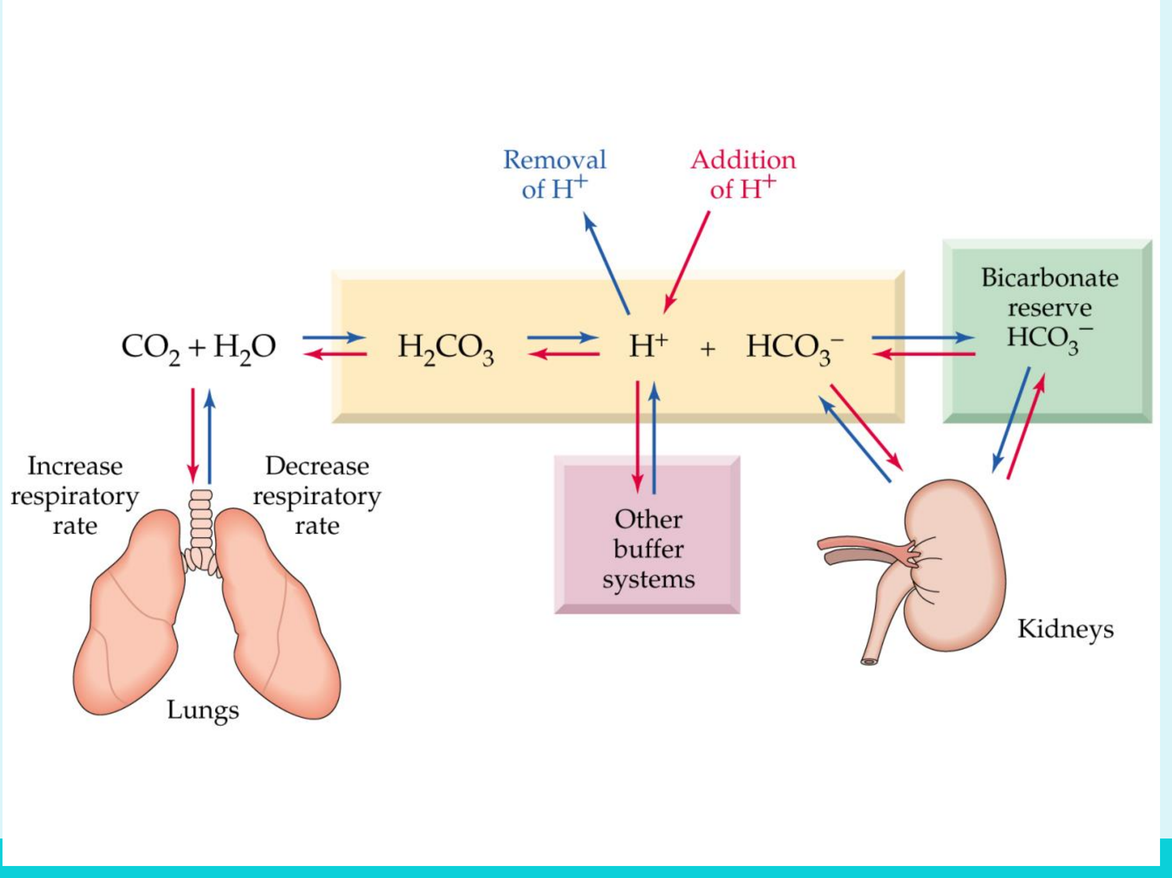
- Body acids;
  - Carbon dioxide (dissolve it in acid → carbonic acid)
  - Lactate

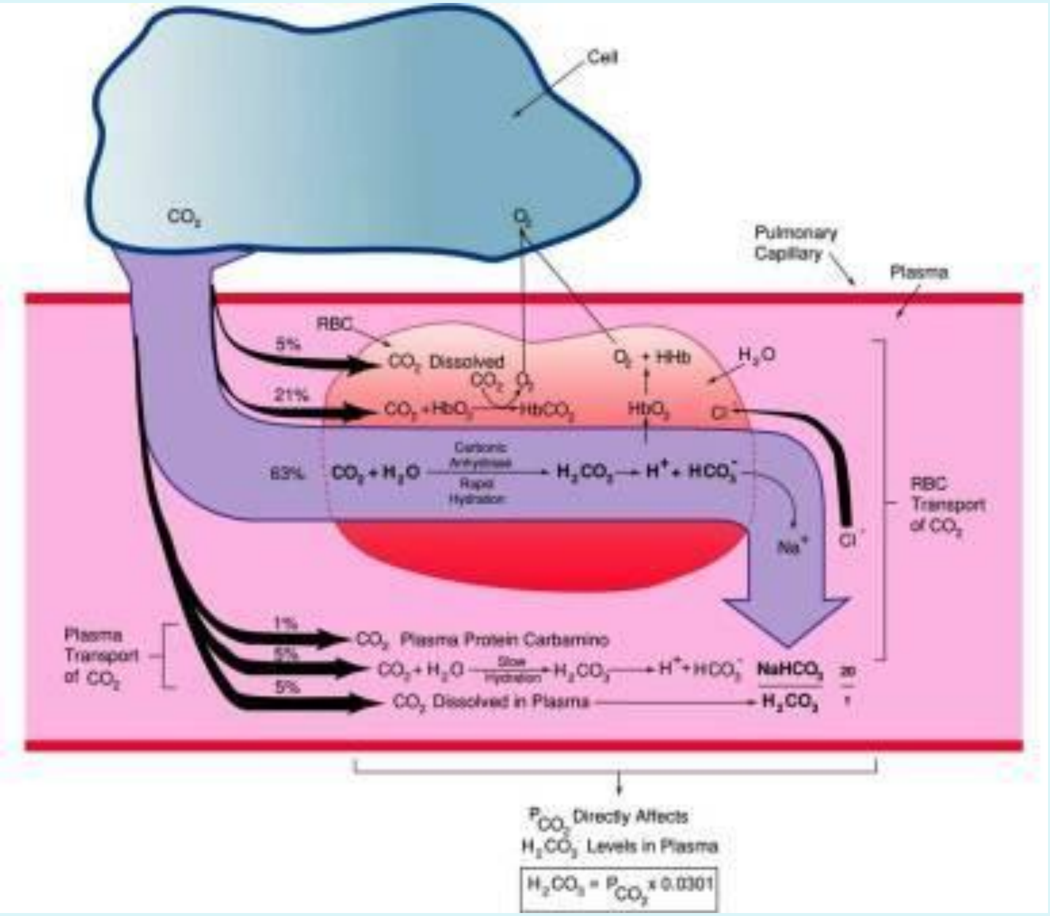




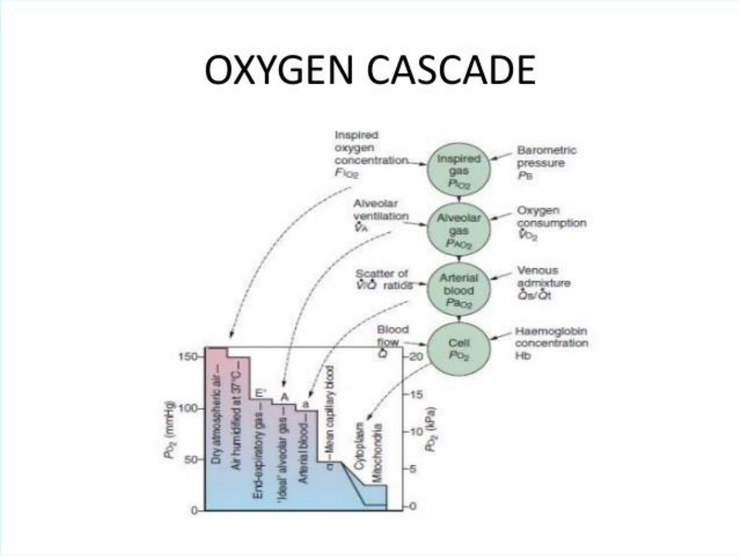
What is involved in acid base balance in the body

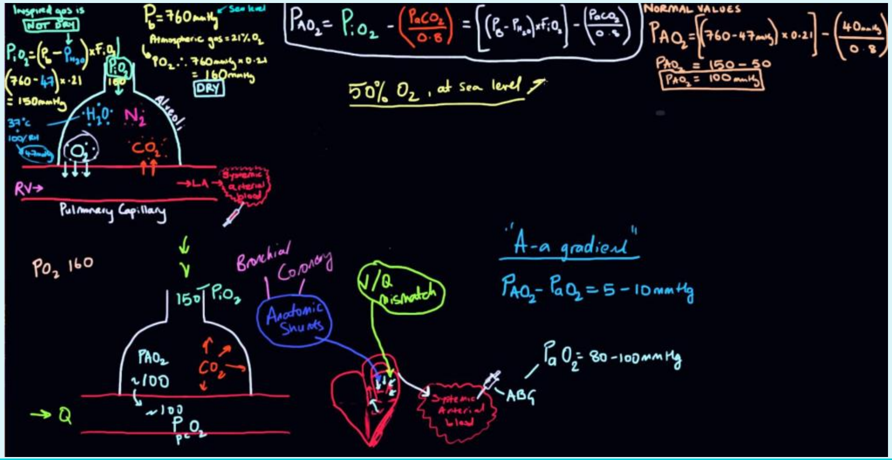
- The bicarbonate buffering system is especially key as it mops up CO_2;

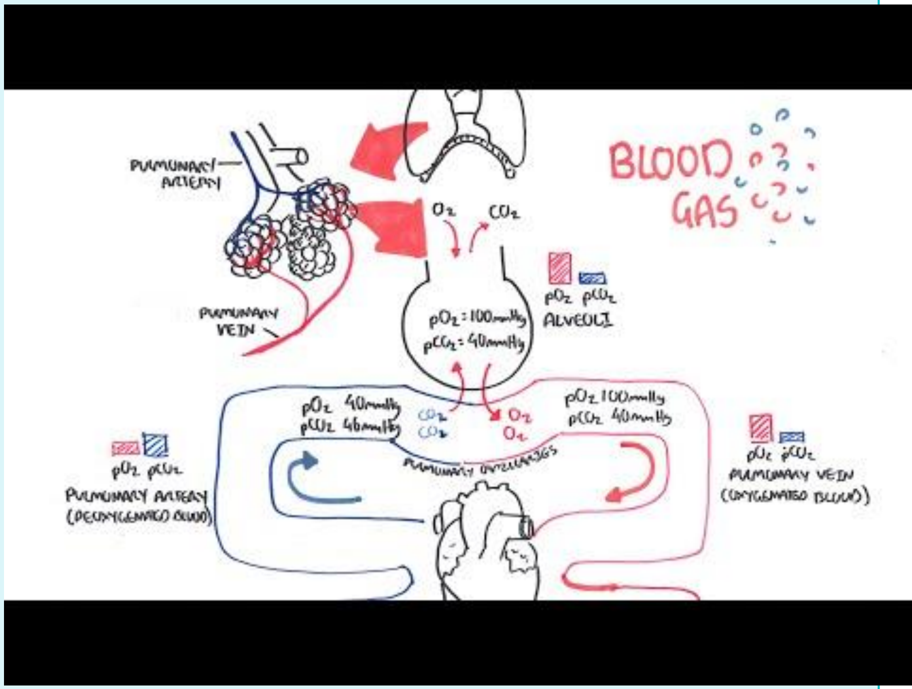



Cell
CO2
O2
Pulmonary Capillary
Plasma
RBC
5%
CO2 Dissolved
O2 + HHb
H2O
21%
CO2 + HbO2 → HbCO2
HbO2
Cl-
63%
CO2 + H2O
Carbonic Anhydrase
Rapid Hydration
→ H2CO3 → H+ + HCO3-
Na+
Cl-
RBC Transport of CO2
Plasma Transport of CO2
1%
CO2 Plasma Protein Carbamino
5%
CO2 + H2O
Slow Hydration
→ H2CO3 → H+ + HCO3-
NaHCO3
20
5%
CO2 Dissolved in Plasma
H2CO3
1
PCO2 Directly Affects
H2CO3 Levels in Plasma
H2CO3 = PCO2 x 0.0301

Oxygenation and Carbon Dioxide

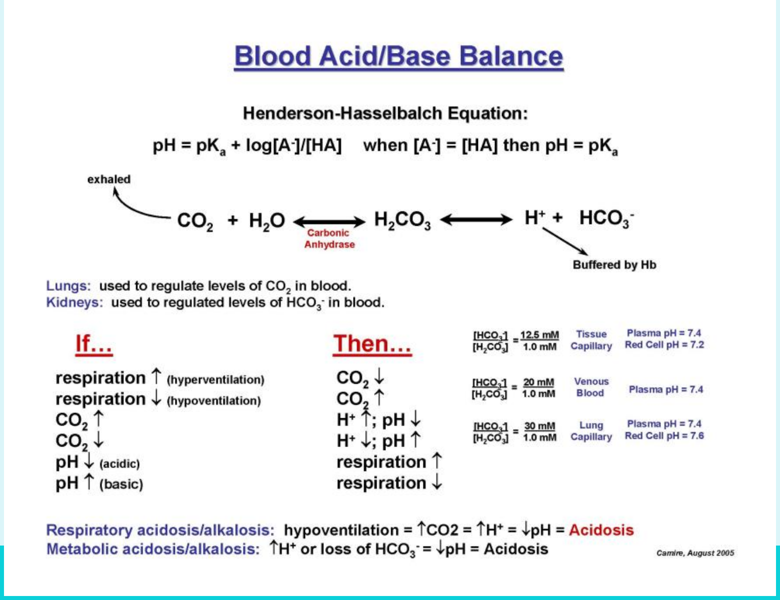


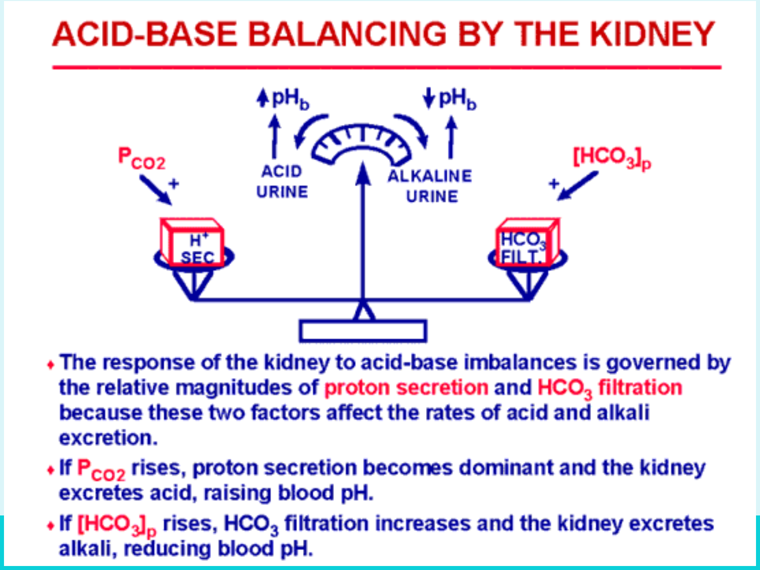




Compensation

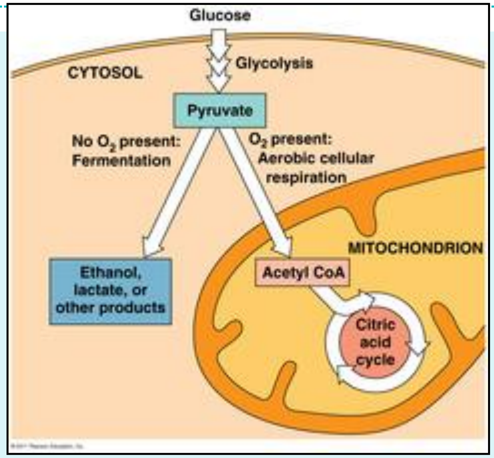
- Ability of body to change the acid-base balance to correct an abnormal pH
- Compensation will occur to correct a deviation from the norm, respiratory is rapid, metabolic is slow

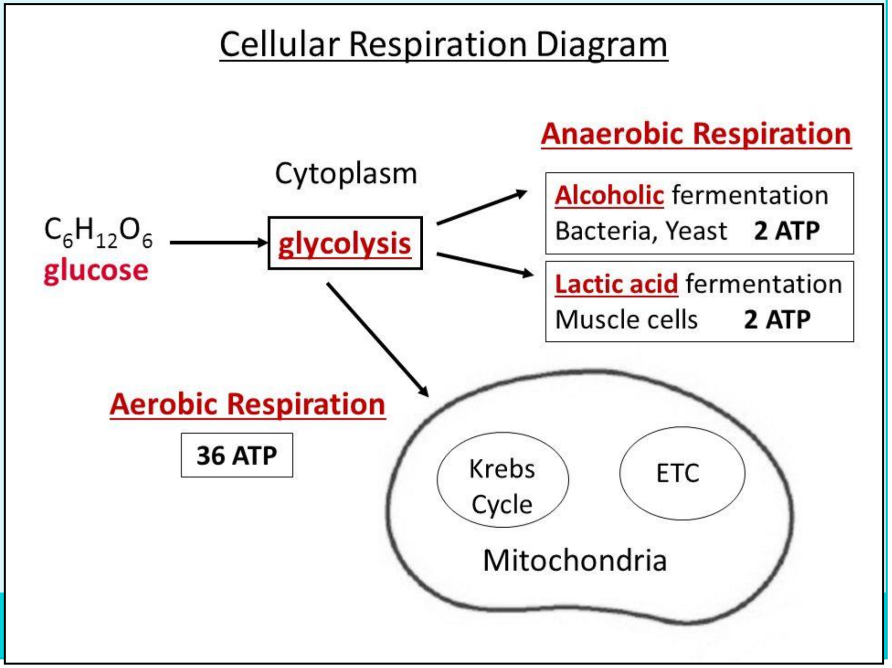




Lactate Production

- Normally <1mmol/L
- Produced when cells have no oxygen → anaerobic metabolism
- In shock, poor perfusion of cells leads to cellular hypoxia → lactate as source of energy
- Good marker of hypoperfusion and resuscitation





Changes in acid base balance in pregnancy

- Increased respiratory rate causes decreased $PaCO_2$
- Causes an alkalosis
- Alterations in bicarbonate levels and chloride levels to compensate
- Reduced haemoglobin levels have a minimal effect

Normal Ranges

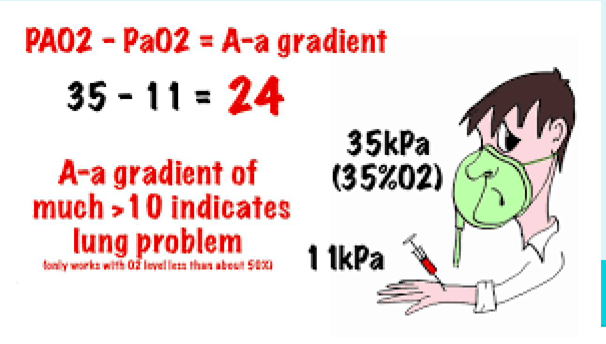
- pH = 7.35 – 7.45
- PCO_2 = 4.5 – 6.0kPa (35-45mmHg)
- PaO_2 = 11.0-13.1 kPa (in normal room air)
- HCO_3 = 22-26mmol/L
- BE = -3 - +3

How do we interpret ABG's

1. How is the patient?
   - Will provide useful clues to help with the interpretation of the results

2. Assess the oxygenation
   - Is the patient hypoxaemic?

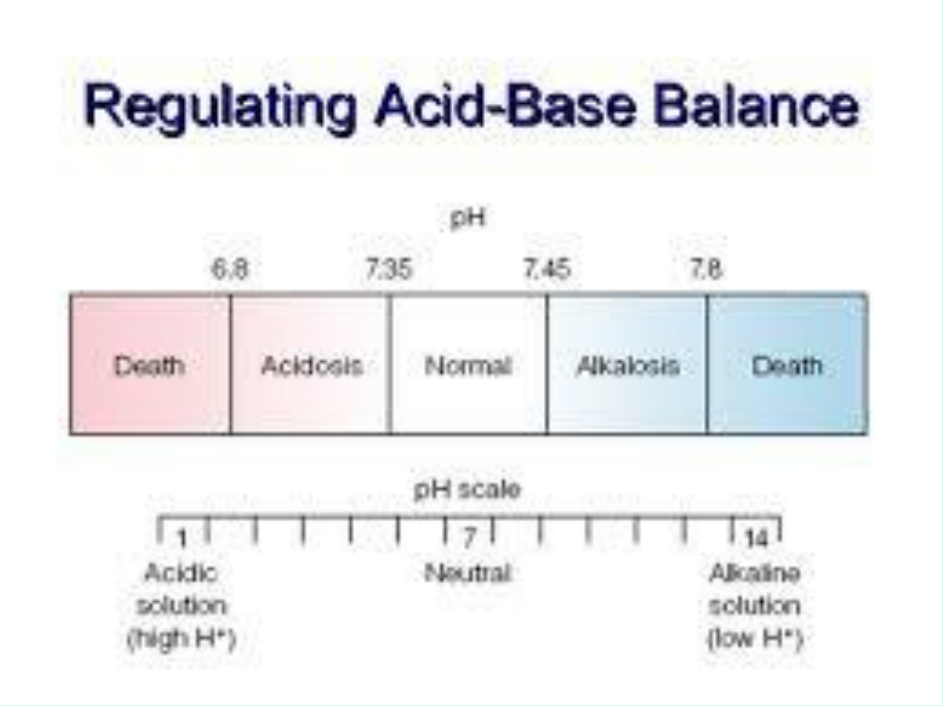
   - The PaO2 should be >10kPa (75mmhg) breathing air and about 10kPa less than the % inspired concentration (oxygen cascade)



3. Determine the state of the pH

>7.45 = alkalaemia; pH<7.45 (H+ >45nmol^{-1})

<7.36 = acidaemia; pH>7.45 (H+ <35nmol l $^{-1}$)



How do we interpret ABG's

4. Determine the respiratory component

$PaCO_2$ = >6.0kPa (45mmHg) respiratory acidosis

< 4.5kPa (35mmHg) respiratory alkalosis

5. Determine the metabolic component

HCO_3 = <22 mmol/l = metabolic acidosis (base excess <-2mmol)

>26 mmol/l = metabolic alkalosis (base excess>+2 mmol l)

	Acidosis	**Alkalosis**
Respiratory	CO_2 increased	CO_2 decreased
Metabolic	HCO_3/BE decreased	HCO_3/BE increased

Scenario 1

A 21-year-old G1 has had a fight with her boyfriend and has been hit on the head. On the way to hospital she has become increasingly drowsy and the paramedics have inserted an oropharyngeal airway and given high-flow oxygen via a face-mask. An arterial blood gas sample has been taken.

- Step 1: How is the patient?
- A SV 40% O2
- B RR 8, Sats 99% on NRB mask
- C brady at 46bpm, BP slightly raised 140/96, CRT normal
- D Pain response only
- E large bruise on right side of head with boggy mass beneath it; fundus not yet measured, no PV loss

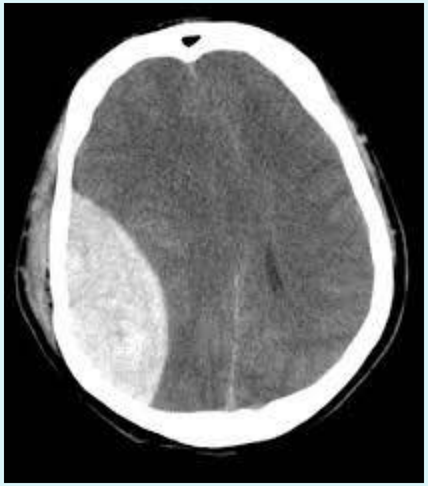
- Arterial blood gas analysis reveals:

Inspired oxygen	40% (FiO_2 0.4)	
		normal values
PaO_2	18.8 kPa	> 10 kPa (75 mmHg) on air
pH	7.19	7.35 – 7.45
$PaCO_2$	10.2 kPa	4.7 – 6.0 kPa
Bicarbonate	23.6 mmol l^{-1}	22 – 26 mmol l^{-1}
Base excess	-2.4 mmol l^{-1}	+/- 2 mmol l^{-1}

- What are you going to do now?
- Step 2: Assess oxygenation
  - Is the patient hypoxaemic?
  - The PaO_2 should be about 10 kPa less than the % inspired concentration

- Step 3: Determine the pH (or H^+ concentration)
  - Is the patient acidaemic; pH < 7.35?
  - Is the patient alkalaemic; pH > 7.45?
- Step 4: Determine the respiratory component
  - If the pH < 7.35, is the $PaCO_2$ > 6.0 kPa (45 mmHg)? – respiratory acidosis
  - If the pH > 7.45, is the $PaCO_2$ < 4.7 kPa (35 mmHg)? – respiratory alkalosis
- Step 5: Determine the metabolic component
  - If the pH < 7.35, is the HCO_3^- < 22 mmol l^{-1} (base excess < -2 mmol l^{-1}) – metabolic acidosis
  - If the pH > 7.45, is the HCO_3^- > 26 mmol l^{-1} (base excess > +2 mmol l^{-1}) – metabolic alkalosis

- In summary, an acute respiratory acidosis with impaired oxygenation



Scenario 2

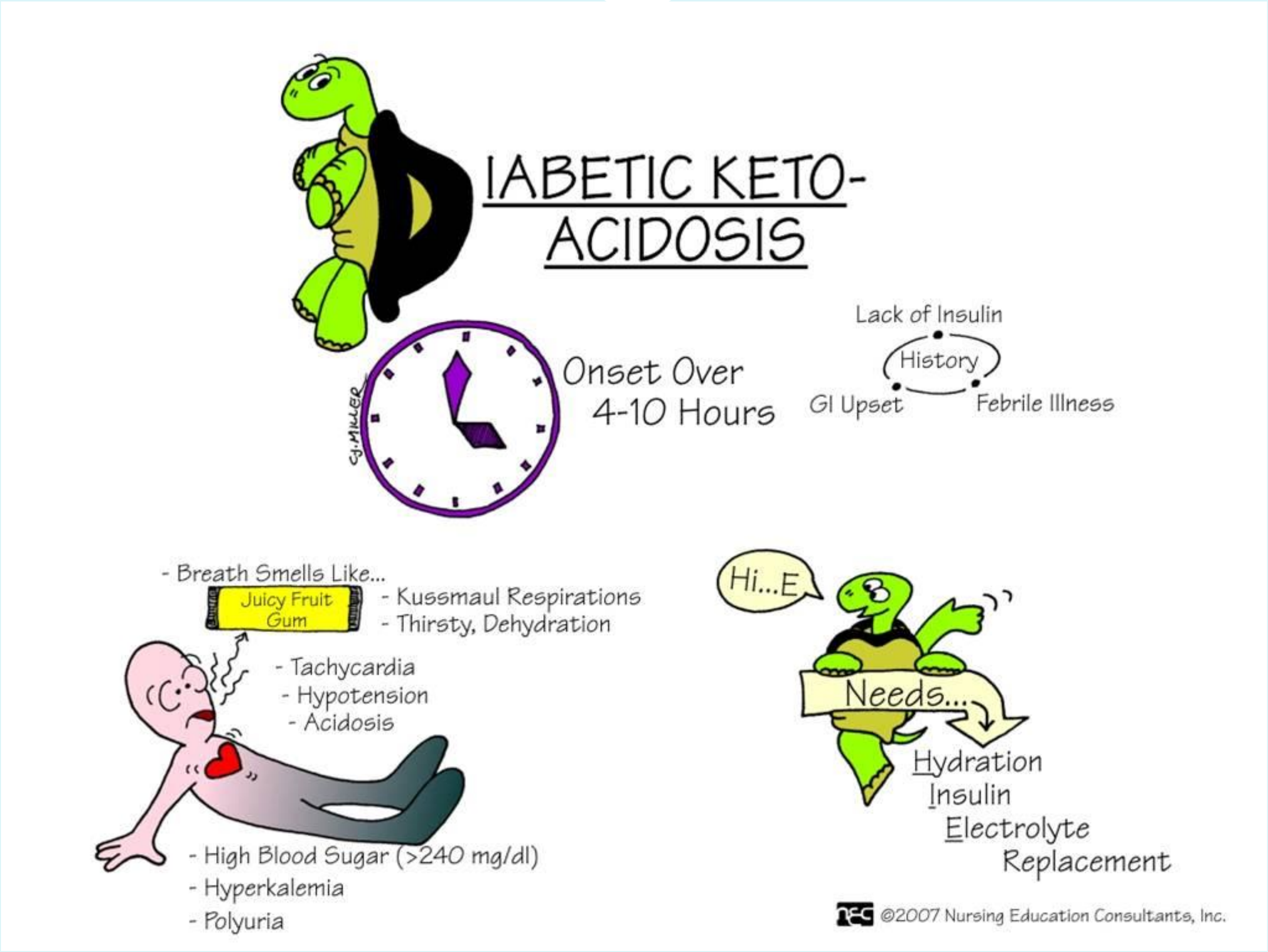
- An 18 year old G1, 35/40 pregnant who is an insulin dependent diabetic is admitted to the day unit. She has been vomiting for 48 hours and because unable to eat, she chose to omit her insulin.
- How is the patient?
- A Patent
- B RR 35bpm SpO2 96% 4l O2 via mask
- C 90/65 Pulse 130 bpm CRT 4 seconds
- D CBG 30mmols. Her GCS is 12 (E3, M5, V4).
- E Fundal height 34cms, long lie, ceph, free, Nil PV Loss

Scenario 2 ABG

- **Arterial blood gas analysis reveals:**

FiO_2	0.3 (30%) estimated	**Normal Values**
pH	6.79	7.35 – 7.45
$PaCO_2$	1.48 kPa (11.3 mmHg)	4.7 – 6.0 kPa (35–45 mmHg)
PaO_2	17.0 kPa (129.2 mmHg)	> 10 kPa (75 mmHg) on air
HCO_3^-	4.7 mmol l^{-1}	22 – 26 mmol l^{-1}
BE	- 29.2 mmol l^{-1}	+/- 2 mmol l^{-1}
Lactate	3mmol/l	<2mmol/l

- The blood glucose is 30 mmol l^{-1} and there are ketones+++ in the urine
- What treatment is indicated?


DIABETIC KETO-ACIDOSIS
C.J. MILLER
Onset Over 4-10 Hours
Lack of Insulin
History
GI Upset
Febrile Illness
- Breath Smells Like...
Juicy Fruit Gum
- Kussmaul Respirations
- Thirsty, Dehydration
- Tachycardia
- Hypotension
- Acidosis
- High Blood Sugar (>240 mg/dl)
- Hyperkalemia
- Polyuria
Hi...E
Needs...
Hydration
Insulin
Electrolyte
Replacement
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Scenario 3

- G2 P2 Post NVD with 2000ml EBL.
- 6 hours postnatal, reported increased PV loss, syntocinon infusion complete and fluid replaced.
- A- SV on air
- B- Resps 28 per minute SaO2 (air 96%)
- C- Pulse 134bpm BP 88/54 CRT greater than 3 mins
- D- AVPU (alert) CBG (BM) not done
- E- Feels warm (temp 38.3C) PV loss moderate, fundus well contracted, Urine output greater than 50 mls per hour

ABG 3

- FiO2 Air
- pH 7.12
- PaCO2- 2.3.0kPa
- PaO2- 16.0 kPa
- BE -2
- Lactate 1

- <u>Normal Values</u>
- pH = 7.35 – 7.45
- PCO_2 = 4.5 – 6.0kPa (35-45mmHg)
- PaO_2 = 11.0-13.1 kPa (in normal room air)
- HCO_3 = 22-26mmol/L
- BE = -3 - +3

ABG3 continued

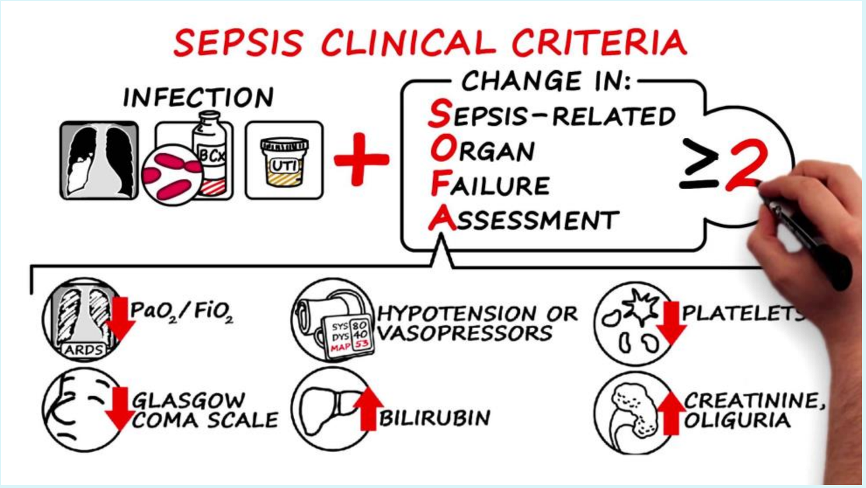
- Although PV loss is stable she continues to deteriorate on the next review (10 hours postnatal)
- A- SV on 28% via humidified O2
- B- Resps 30 per minute SaO2 96% on O2 (had gone down to 90%
- C- Pulse 140 bpm (sinus tachycardia on ECG) BP 80/46 CRT 4 seconds
- D- Responds to voice
- E- Despite IVAB's, paracetamol (post septic screen) Temp 38.6C Urine output 35mls/hour

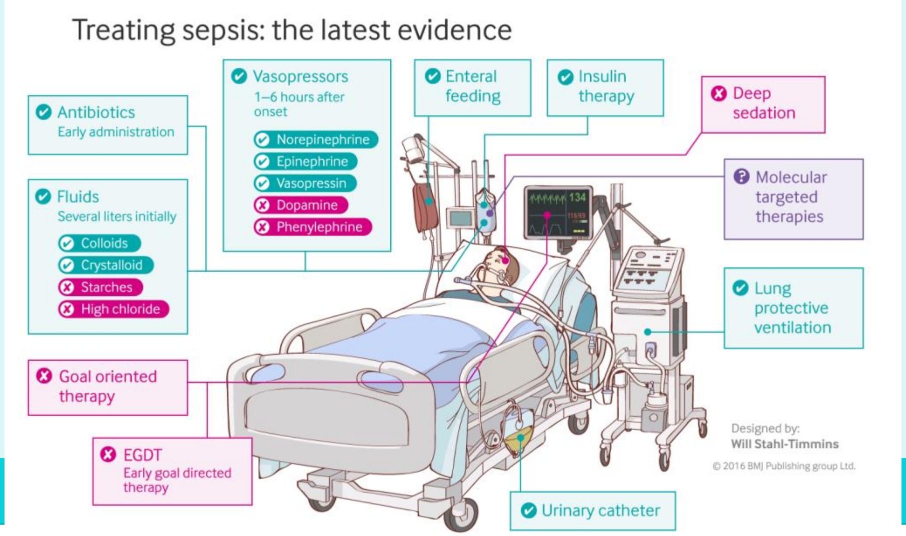
ABG 3

- Current ABG:
- FiO2 (28%)
- pH 7.0
- PaCO2- 1.6kPa
- PaO2- 18.0kPa
- BE- -4
- Lactate 4

- (Four hours earlier) FiO2 Air
- pH 7.12
- PaCO2- 2.3.0kPa
- PaO2- 16.0 kPa
- BE -2
- Lactate 1

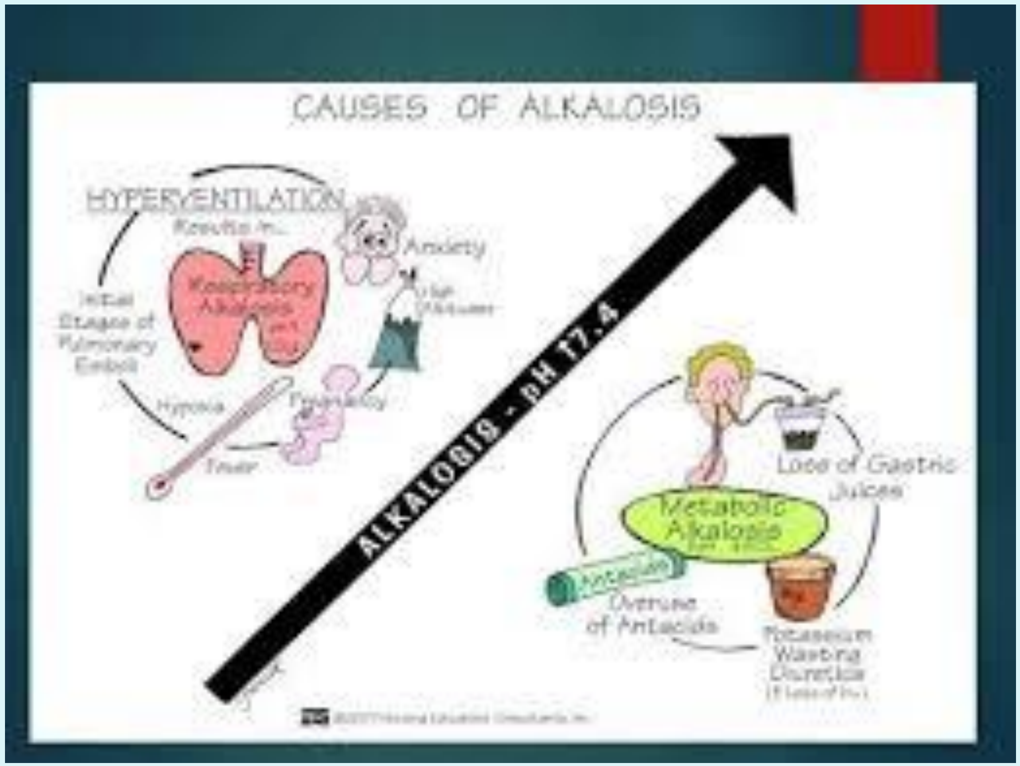
Sepsis physiology and changes





Hyperventilation Picture

Resp and metabolic alkalosis



In summary

- Use a systematic approach to interpretation of ABG's assessing the respiratory and renal component.

ABG	pH	$PaCO_2$	HCO_3
Respiratory Acidosis	↓	↑	normal
Respiratory Alkalosis	↑	↓	normal
Metabolic Acidosis	↓	normal	↓
Metabolic Alkalosis	↑	normal	↑