Step-by-step guide on how to read ABG/VBGs:

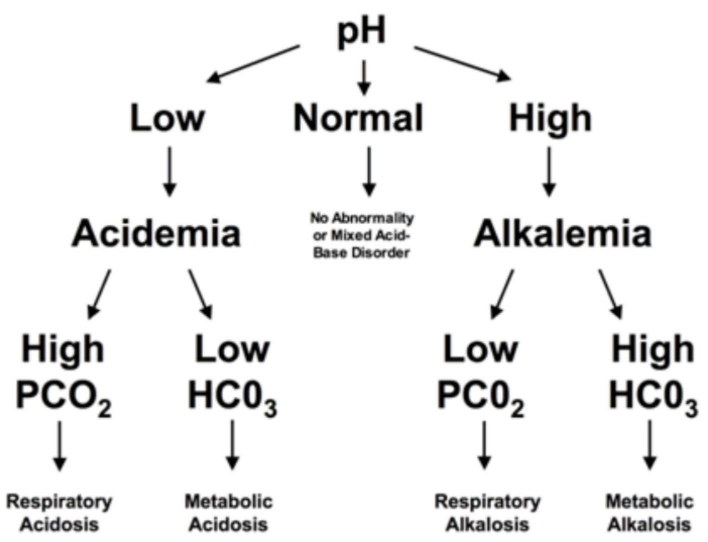
1. Learn the ranges ahead of time: very, very, useful

- **pH:** 7.35-7.45
- **PaO_2:** 80-100 mmHg
  - PaO_2 should be ~5x your FiO2, so at 21% oxygen (room air), PaO_2 should be ~100 mmHg
- **$PaCO_2$:** 35-45 mmHg
- **HCO_3:** 22-26 mmol/L
- **Base excess:** -2 to 2 ← not useful
- **Anion gap:** 8 ± 4 (i.e. 4-12, when not using K+)

2. Buy yourself time by confirming that you are in fact looking at an ABG and not a VBG and that it is for the correct patient
3. If it is an ABG check pO_2 levels, do this first as it is the easiest to correct
   a. Airway support
   b. Supplemental O_2
4. Check the pH and compare it to the range, low = acidic, high = alkalotic
5. Check either CO_2 or HCO_3^-, either one does not matter which is first

Increased CO_2 **OR** decreased HCO_3 → **acidosis**

Decreased CO_2 **OR** increased HCO_3 → **alkalosis**

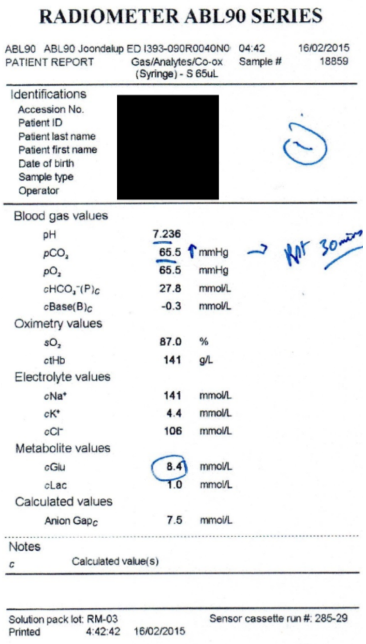


Compensation (general rules):

- **pH** ↓ (acidosis) **+ HCO_3** ↓ (metabolic) → **CO_2** will be **low** to compensate
- **pH** ↓ (acidosis) **+ CO_2** ↑ (respiratory) → **HCO_3** will be **high** to compensate

- **pH** ↑ (alkalosis) **+ HCO_3** ↑ (metabolic) → **CO_2** will be **high** to compensate
- **pH** ↑ (alkalosis) **+ CO_2** ↓ (respiratory) → **HCO_3** will be **low** to compensate

i.e. the compensation will follow the change



RADIOMETER ABL90 SERIES

ABL90 ABL90 Joondalup ED I393-090R0040N0 04:42 16/02/2015
PATIENT REPORT Gas/Analytes/Co-ox (Syringe) - S 65uL Sample # 18859

Identifications
Accession No.
Patient ID
Patient last name
Patient first name
Date of birth
Sample type
Operator
[redacted]

Blood gas values		
pH	7.236	
pCO_2	65.5 ↑	mmHg
pO_2	65.5	mmHg
$cHCO_3^-(P)_c$	27.8	mmol/L
$cBase(B)_c$	-0.3	mmol/L
Oximetry values		
sO_2	87.0	%
ctHb	141	g/L
Electrolyte values		
cNa^+	141	mmol/L
cK^+	4.4	mmol/L
cCl^-	106	mmol/L
Metabolite values		
cGlu	8.4	mmol/L
cLac	1.0	mmol/L
Calculated values		
Anion Gap_c	7.5	mmol/L

Notes
c Calculated value(s)

Solution pack lot RM-03 Sensor cassette run #: 285-29
Printed 4:42:42 16/02/2015

e.g. for this ABG, we can see that:

1. O_2 is low, needs supplemental O_2
2. pH is decreased (acidosis)
3. pCO_2 is increased (respiratory)
4. HCO_3 is also increased (compensation)

This patient is in **type II respiratory failure**

Hypothetically, if we looked at HCO_3 first we would realise that an increased HCO_3 would not cause an acidosis, so it must be compensating.

Specific scenarios

Metabolic Acidosis

1. Check anion gap
   a. Anion gap represents the total amount of unmeasured anions and is equal to $([Na^+] + [K^+]) - ([Cl^-] + [HCO_3^-])$ and usually has a range of 4 – 12 mmol/L (K^+ is very rarely added as in practice offers little advantage)
   b. It is a way of measuring the quantity of electrolytes/large proteins that do not appear on an ABG such as albumin and phosphate

Causes of high anion gap metabolic acidosis (HAGMA): Left total knee replacement – **LTKR**

- **L**actate: sepsis, anaerobic metabolism
- **T**oxins: methanol, ethylene glycol, salicylates, isoniazid, iron
- **K**etones elevated: DKA, alcoholic ketoacidosis, starvation (rare)
- **R**enal: uraemia/renal failure

Causes of normal anion gap metabolic acidosis (NAGMA): **ABCD**

- **A**ddison's or low **al**bumin
- **B**icarbonate loss: vomiting, renal tubular acidosis (type 1,2, and 4), diarrhoea
- **C**hloride excess: excess saline
- **D**iuretics: acetazolamide

How to show-off on placement:

Winter's formula:

Used in metabolic acidosis to predict expected pCO_2 from the HCO_3^- to decide if it is a mixed metabolic disorder.

- i.e. are the patients working hard enough to blow off the excess CO_2 or are they experiencing respiratory failure as well?

$$Expected\ pCO_2 = (1.5 \times HCO_3^-) + 8 \pm 2\ mmHg$$

Used to determine: is there adequate respiratory compensation?

Metabolic Alkalosis

Causes of metabolic alkalosis: caused by relative loss of H^+ or potassium loss → ↑ K^+/H^+ anti-porter → ↑ K^+ + ↓ H^+

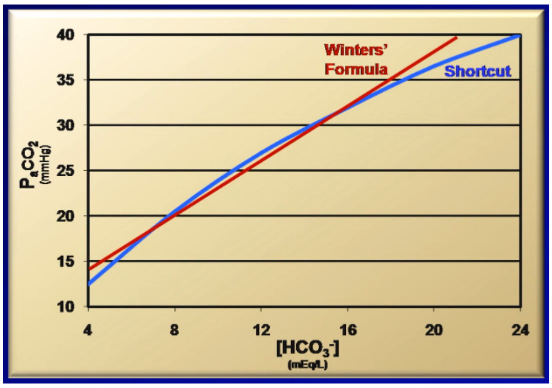
- **D**iuretics: renal loss of K^+ and H^+
- **O**verdose of base: HCO_3^- given for TCA overdoses, antacids, laxatives
- **GI** loss: vomiting, NG tube aspiration
- **E**ndocrine: Cushing's, steroids, hyperaldosteronism

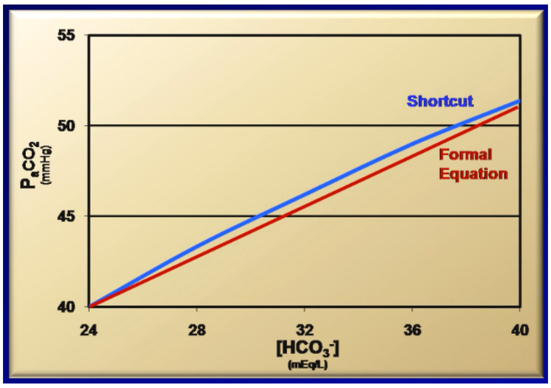
Compensation formula, not as commonly used:

$$Expected\ pCO_2 = (0.7 \times HCO_3^-) + 20\ mmHg$$

Compensation pCO_2 shortcut for metabolic acidosis or alkalosis:

Shortcut (don't need to use the equations): pCO_2 ≈ the last two digits of the pH, e.g., if pH = 7.26, expected pCO_2 will be 26 mmHg, reasonable accuracy:





Respiratory Acidosis

Caused by the lungs not breathing off CO_2 and allowing accumulation of acid, so anything that causes decreased ventilation leads to respiratory acidosis.

- Central respiratory depression
- Drug depression of respiratory centre (e.g. by opiates, sedatives, anaesthetics)
- Neuromuscular disorders

- Lung or chest wall defects
- Airway obstruction
- Inadequate mechanical ventilation

Also occurs with increased catabolism (hypercatabolic disorders → over-production of CO_2 or increased intake of CO_2)

Respiratory Alkalosis

Caused by breathing off too much CO_2 i.e. increased respiratory rate.

- Anxiety, panic attack
- Pain
- PE
- Pneumothorax
- Iatrogenic: mechanical ventilation
- Aspirin toxicity
- Fibrosis: increase RR to increase O_2, but side-effect is blowing off extra CO_2

The 1-2-3-4-5 rule

	HCO3 (Baseline 24 mmol/L)	
Every **10 mmHg** change in PaCO2 from *baseline* 40 mmHg	ACUTE	CHRONIC
↑PaCO2	**1**	**4**
↓PaCO2	**2**	**5**

Unlike in CO_2 in metabolic acidosis/alkalosis: HCO_3 takes time to compensate, as the kidneys work slowly to retain HCO_3.

To predict whether the respiratory condition is acute or chronic. For example, helpful in patients with ?COPD as you can work out if this is worse than their baseline or a chronic process.

Base excess

Not important

Arterial Blood Gas Analysis

ABG Parameter			ABG result
pH	>7.45	Alkalaemia	
	7.36-44	Normal	
	<7.35	Acidaemia	
pCO2	>45	High	
	35-45	Normal	
	<35	Low	
HCO3	>26	High	
	24+/- 2	Normal	
	<22	Low	
AG	> 16	High	
	12+/-4	Normal	
	< 8	Low	
Glucose	>10	High	
	< 2	Low	
Gap: Gap	$\frac{\Delta AG}{\Delta HCO_3} = \frac{AG - 12}{24 - HCO_3}$		
Lactate	**<1.9**	Normal	
	>2.0	High	
pO2	80-100	Normal	
	< 80	Hypoxia	

Calculation and interpretation		
pH	**pCO2**	**Interpretation**
↓	↓	Metabolic acidosis
↑	↑	Metabolic alkalosis
↑	↓	Respiratory alkalosis
↓	↑	Respiratory acidosis
Corrected standard AG for albumin		
$\frac{\text{Albumin}}{4} + 1.5 \times \text{Phosphate}$		
Anion Gap calculation		
$\{[Na^+] - [Cl^- + HCO_3]\} = 12+/-4$		
Corrected Na+ for AG in hyperglycemia		
$\text{Corrected } Na^+ = Na + \frac{\text{Glucose} - 5}{3}$		
Gap: Gap calculation for metabolic acidosis		
<0.4	Low or Normal AG metabolic acidosis	
0.4-0.8	Normal + high AG metabolic acidosis	
0.8-2.0	Pure high metabolic acidosis	
>2.0	Metabolic acidosis with metabolic alkalosis/respiratory acidosis	
$PAO2 = [713 \times FiO2] - [pCO2 \times 1.25]$		
A-a gradient = $PAO2 - PaO2 = \frac{Age}{4} + 4$		

Compensation rules for				
	Metabolic acidosis		**Metabolic alkalosis**	
Expected PCO2	1.5 X [HCO3] + 8 (+/- 2)		0.7 X [HCO3] + 20 (+/- 5)	
	Respiratory acidosis		**Respiratory alkalosis**	
	Acute	Chronic	Acute	Chronic
Expected HCO3	$24 + \frac{pCO2 - 40}{10} \times 1$	$24 + \frac{pCO2 - 40}{10} \times 4$	$24 - \frac{40 - pCO2}{10} \times 2$	$24 - \frac{40 - pCO2}{10} \times 5$