

# ABGs and Acid Base Imbalance

## Normal Values

- pH: 7.35-7.45
- PaCO<sub>2</sub>: 35-45 mmHg
- HCO<sub>3</sub><sup>-</sup>: 22-26 mEq/L

## Steps For Interpretation

1. Is the pH high or low?
2. CO<sub>2</sub> will go the opposite direction to the pH if there is a primary respiratory problem.
3. HCO<sub>3</sub><sup>-</sup> will go in the same direction as the pH if there is a primary metabolic problem.
4. Everything going the same direction: respiratory compensation for a metabolic problem.
5. CO<sub>2</sub> and HCO<sub>3</sub><sup>-</sup> going the opposite direction to the pH: metabolic compensation for a respiratory problem.
6. If the pH is in the normal range, but both CO<sub>2</sub> and HCO<sub>3</sub><sup>-</sup> are abnormal, there is full compensation, the original issue will be the end of the normal range the pH is closest to.

	ABG Findings	Causes
<b>Metabolic Alkalosis</b>	<b>Uncompensated</b> <ul style="list-style-type: none"> <li>- pH &gt;7.35</li> <li>- HCO<sub>3</sub><sup>-</sup> High</li> <li>- PaCO<sub>2</sub> Normal</li> </ul> <b>Compensation</b> <ul style="list-style-type: none"> <li>- pH &gt;7.35 or N</li> <li>- HCO<sub>3</sub><sup>-</sup> High</li> <li>- PaCO<sub>2</sub> High</li> </ul>	<ul style="list-style-type: none"> <li>- Vomiting</li> <li>- Potassium depletion (e.g. diuretics)</li> <li>- Burns</li> <li>- Ingestion of basic substances (e.g. cleaning products)</li> </ul>
<b>Respiratory Alkalosis</b>	<b>Uncompensated</b> <ul style="list-style-type: none"> <li>- pH &gt;7.35</li> <li>- HCO<sub>3</sub><sup>-</sup> Normal</li> <li>- PaCO<sub>2</sub> Low</li> </ul> <b>Compensation</b> <ul style="list-style-type: none"> <li>- pH &gt;7.35 or N</li> <li>- HCO<sub>3</sub><sup>-</sup> Low</li> <li>- PaCO<sub>2</sub> Low</li> </ul>	<ul style="list-style-type: none"> <li>- Due to hyperventilation of any cause</li> <li>- CNS (SAH, Stroke, Meningitis)</li> <li>- Asthma</li> <li>- Anxiety</li> <li>- Altitude</li> <li>- Pregnancy</li> <li>- PE</li> <li>- Drugs e.g. salicylates</li> </ul>
<b>Metabolic Acidosis</b>	<b>Uncompensated</b> <ul style="list-style-type: none"> <li>- pH &lt;7.35</li> <li>- HCO<sub>3</sub> Low</li> <li>- PaCO<sub>2</sub> Normal</li> </ul> <b>Compensation</b> <ul style="list-style-type: none"> <li>- pH &lt;7.35 or N</li> <li>- HCO<sub>3</sub> Low</li> <li>- PaCO<sub>2</sub> Low</li> </ul>	<ul style="list-style-type: none"> <li>- <b>Increased H<sup>+</sup> Production:</b> <ul style="list-style-type: none"> <li>- DKA</li> <li>- Lactic Acidosis</li> </ul> </li> <li>- <b>Decreased H<sup>+</sup> Excretion</b> <ul style="list-style-type: none"> <li>- Renal Failure</li> <li>- Renal Tubular Acidosis</li> </ul> </li> <li>- <b>Loss of HCO<sub>3</sub><sup>-</sup></b> <ul style="list-style-type: none"> <li>- Diarrhoea</li> <li>- Pancreatic fistula</li> <li>- Renal Tubular Acidosis</li> </ul> </li> </ul>

	ABG Findings	Causes
<b>Respiratory Acidosis</b>	<p><b>Uncompensated</b></p> <ul style="list-style-type: none"> <li>- pH &lt;7.35</li> <li>- HCO<sub>3</sub><sup>-</sup> Normal</li> <li>- PaCO<sub>2</sub> High</li> </ul> <p><b>Compensation</b></p> <ul style="list-style-type: none"> <li>- pH &lt;7.35 or N</li> <li>- HCO<sub>3</sub><sup>-</sup> High</li> <li>- PaCO<sub>2</sub> High</li> </ul>	<ul style="list-style-type: none"> <li>- <b>Respiratory Centre Depression</b> <ul style="list-style-type: none"> <li>- Drugs (anaesthetics, sedatives, narcotics)</li> <li>- Trauma</li> <li>- Raised ICP</li> <li>- Encephalitis</li> <li>- Stroke</li> </ul> </li> <li>- <b>Neuromuscular Disorders</b> <ul style="list-style-type: none"> <li>- Myasthenia Gravis</li> <li>- Guillain-Barre</li> <li>- Poliomyelitis</li> <li>- Muscular dystrophies</li> <li>- MND</li> <li>- Myopathies</li> <li>- Chest wall disease (obesity, kyphoscoliosis, Ankylosing Spondylitis)</li> </ul> </li> <li>- <b>Lung Disease</b> <ul style="list-style-type: none"> <li>- Obstructive: COPD, Asthma</li> <li>- Restrictive: Late stage ILD</li> <li>- Pulmonary Oedema</li> <li>- Pneumothorax</li> <li>- Pneumonia</li> <li>- ARDS</li> </ul> </li> </ul>

## Anion Gap

Metabolic acidosis can also be considered as having a normal or increased anion gap. This allows further delineation of causes, making diagnosis more straightforward. An increased anion gap occurs when there is increased production or a decreased in excretion of fixed/organic acids.

### Increased Anion Gap Metabolic Acidosis

- Lactic Acidosis: shock, infection, ischaemia
- Urate: renal failure
- Ketoacidosis: diabetes mellitus, alcohol
- Drugs/Toxins: salicylates, biguanides, ethylene glycol, methanol

### Normal Anion Gap Metabolic Acidosis

- Renal tubular acidosis
- Diarrhoea
- Drugs (acetazolamide)
- Addison's disease
- Pancreatic fistula
- Ammonium chloride ingestion

## Want More Practice?

I highly recommend <http://abg.ninja/abg> for practicing ABG interpretation. It generates random ABG results that you can interpret, and explains the results once you've attempted them.

### References:

Longmore, M, Wilkinson IB, Baldwin, A & Wallin, E 2014, *Oxford Handbook of Clinical Medicine*, 9th edn, Oxford University Press, Oxford, p. 684.

Kin, J & Mukovozov, I 2017, *Toronto Notes*, 33rd edn, Toronto Notes for Medical Students, Toronto, pp. R5-6.