Blood Gases Made Easy

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Life is all about balance...
37 ± 0.5°C
Similarly, the pH of body fluids is optimized, in particular blood pH...
Acid – Base Balance

0 Acid 7 Alkali (Base) 14

\[ \text{pH} = \log_{10} \left( \frac{1}{[H^+]} \right) \]

Acidosis 7.40 Alkalosis
Acid – Base Balance

7.35 – 7.45

Acidosis  Normal  Alkalosis

Arterial blood pH

Patient A  7.28  Acidosis
Patient B  7.51  Alkalosis
Patient C  7.34  Acidosis
Patient D  7.46  Alkalosis
Acid – Base Balance

Henderson – Hasselbach equation

$$pH = 6.1 + \log_{10} \left( \frac{[\text{HCO}_3^-]}{0.03 \times p\text{CO}_2} \right)$$
Acid – Base Balance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal range</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.35 – 7.45</td>
</tr>
<tr>
<td>pCO₂</td>
<td>35 – 45 mmHg</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>22 – 26 mmol/L</td>
</tr>
</tbody>
</table>

\[
pH = 6.1 + \log_{10}\left(\frac{[\text{HCO}_3^-]}{0.03 \times \text{pCO}_2}\right) \]

\[
pH = 7.40
\]
Acid – Base Balance

7.35 – 7.45

Acidosis

High $pCO_2$
Low $HCO_3^-$

Alkalosis

Low $pCO_2$
High $HCO_3^-$
Acid – Base Balance

\[ pH \propto \left( \frac{\text{HCO}_3^-}{p\text{CO}_2} \right) \]

Metabolic

Respiratory
Acid – Base Balance

Le Chatelier’s principle

\[
\text{CO}_2 + \text{H}_2\text{O} \leftrightarrow \text{H}_2\text{CO}_3 \leftrightarrow \text{H}^+ + \text{HCO}_3^-
\]
Acid – Base Balance

7.35 – 7.45

Acidosis

- High pCO₂
- Low HCO₃⁻

- Respiratory Acidosis
- Metabolic Acidosis

Alkalosis

- Low pCO₂
- High HCO₃⁻

- Respiratory Alkalosis
- Metabolic Alkalosis
### Acid – Base Balance

#### Normal range

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>pCO₂</th>
<th>HCO₃⁻</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>7.35</td>
<td>35</td>
<td>22</td>
</tr>
<tr>
<td>High</td>
<td>7.45</td>
<td>45 mmHg</td>
<td>26 mmol/L</td>
</tr>
</tbody>
</table>

#### Acid-Base Imbalance

<table>
<thead>
<tr>
<th>Patient</th>
<th>pH</th>
<th>pCO₂</th>
<th>HCO₃⁻</th>
<th>Diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7.28</td>
<td>51</td>
<td>23</td>
<td>Respiratory Acidosis</td>
</tr>
<tr>
<td>B</td>
<td>7.51</td>
<td>32</td>
<td>25</td>
<td>Respiratory Alkalosis</td>
</tr>
<tr>
<td>C</td>
<td>7.30</td>
<td>40</td>
<td>19</td>
<td>Metabolic Acidosis</td>
</tr>
<tr>
<td>D</td>
<td>7.55</td>
<td>35</td>
<td>30</td>
<td>Metabolic Alkalosis</td>
</tr>
</tbody>
</table>

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Acid – Base Balance Compensation

<table>
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<tr>
<th>pH</th>
<th>pCO₂</th>
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</table>

3 responses to the change in equilibrium

1. Buffers in the blood
2. Respiratory
3. Metabolic

Response time

Quickly
Fairly quickly
Slowly
Acid – Base Balance Compensation

3 responses to the change in equilibrium

1. Buffers in the blood

![Graph showing pH change with acid and base added]
Acid – Base Balance Compensation

3 responses to the change in equilibrium

1. Buffers in the blood
2. Respiratory

\[ pH \propto \left( \frac{\text{HCO}_3^-}{p\text{CO}_2} \right) \]
Acid – Base Balance Compensation

3 responses to the change in equilibrium

1. Buffers in the blood
2. Respiratory
3. Metabolic

\[ pH \propto \left( \frac{\text{HCO}_3^-}{p\text{CO}_2} \right) \]
Acid – Base Balance Compensation

7.35 – 7.45

Acidosis → Increase \( \text{HCO}_3^- \) → Low \( p\text{CO}_2 \) → Alkalosis

High \( p\text{CO}_2 \) → Decrease \( \text{HCO}_3^- \) → Alkalosis → High \( p\text{CO}_2 \)
Acid – Base Balance Compensation

7.35 – 7.45

Acidosis → Decrease pCO₂ → Low HCO₃⁻

Alkalosis → Increase pCO₂ → High HCO₃⁻
<table>
<thead>
<tr>
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<th>7.45</th>
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<tbody>
<tr>
<td><strong>pH</strong></td>
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</tr>
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<td><strong>HCO₃⁻</strong></td>
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### Arterial blood pH

<table>
<thead>
<tr>
<th></th>
<th>ACID</th>
<th>NORMAL</th>
<th>BASE</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.35</td>
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<td>HCO₃⁻</td>
<td>22</td>
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**Patient A**

- pH: 7.28
- pCO₂: 51
- HCO₃⁻: 23

**Uncompensated Respiratory Acidosis**
# Arterial blood pH

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<td>22</td>
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**Patient B**

- pH: 7.70
- pCO₂: 24
- HCO₃⁻: 21

**Partially compensated Respiratory Alkalosis**
# Arterial blood pH

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<td>HCO₃⁻</td>
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<td></td>
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</tbody>
</table>

**Patient C**
- pH: 7.45
- pCO₂: 48
- HCO₃⁻: 28

**Fully compensated Metabolic Alkalosis**
Arterial blood pO$_2$

Normal range for pO2 in arterial blood is 80 – 100 mmHg
(assuming room air at sea level of circa 160 mmHg)

Mexico City
Altitude 2240 metres, BP 585mmHg
Room air pO$_2$ circa 123 mmHg
Normal range 62 to 77 mmHg

60 - 79 mmHg mild hypoxia
40 - 59 mmHg moderate hypoxia
< 40 mmHg severe hypoxia
Arterial blood pO$_2$

For a patient on oxygen therapy the FiO$_2$ has to considered…

<table>
<thead>
<tr>
<th>FiO$_2$</th>
<th>Expected pO2 mmHg</th>
</tr>
</thead>
<tbody>
<tr>
<td>30%</td>
<td>150</td>
</tr>
<tr>
<td>40%</td>
<td>200</td>
</tr>
<tr>
<td>50%</td>
<td>250</td>
</tr>
</tbody>
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Rule of 5X
Blood Gas Interpretation

This is a basic guide to ABG result interpretation
Real life situations are often more complex

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Additional calculated parameters such as Anion Gap, tHb & SaO₂ can help diagnose root cause
Thank you for your attention