Arterial Blood Gas Analysis & Interpretation
**ABG = Arterial Blood Gas**

It is estimation of different blood gas component in arterial blood. E.g.
- partial pressure of oxygen (pO2)
- pCO2
- pH
- Conc. Of HCO3
- Base Excess (BE)
- SpO2

Which is an essential to manage the patient’s oxygenation status as well as patient on ventilation and diagnose acid base balance.
Principle

- By the specific electrode particular gas component is diffused through the membrane & it will make change in electrical potential.
- That change in electrical potential reflect concentration of gas in Blood.
Principle

Oxygen electrode

- Silver/silver chloride anode
- Electrolyte
- Platinum cathode
- Plastic membrane

Blood specimen or gas
Normal Arterial Blood Gas Values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>7.35 - 7.45</td>
</tr>
<tr>
<td>PaCO₂</td>
<td>32 - 36 mm Hg</td>
</tr>
<tr>
<td>PaO₂</td>
<td>90 - 100 mm Hg</td>
</tr>
<tr>
<td>SaO₂</td>
<td>95 - 100%</td>
</tr>
<tr>
<td>HCO₃⁻</td>
<td>22 - 26 mEq/L</td>
</tr>
<tr>
<td>Base excess</td>
<td>-2.0 to 2.0 mEq/L</td>
</tr>
</tbody>
</table>
pH

- Not a gas
- But a measurement of acidity or alkalinity, based on the hydrogen (H+) ions concentration in blood.
- The pH of a solution is equal to the negative log of the hydrogen ion concentration in that solution:

\[ \text{pH} = - \log [\text{H}^+] \]
**pO2**

- The partial pressure of oxygen that is dissolved in arterial blood.
  New Born – Acceptable range 40-70 mmHg.
- PO2 determination is carried out to assess the O2 carrying capacity of blood Hb.
- A low pO2 is measure of Hypoxia .
- A low pO2 with high pCO2 may also be observed in pulmonary edema.
**HCO₃**

- The calculated value of the amount of bicarbonate in the bloodstream.
- Not a blood gas but the anion of carbonic acid.

Hco₃ = [pCO₂] antilog [pH - pK’a]
SpO2

- The arterial oxygen saturation with haemoglobin.
The amount of carbon dioxide dissolved in arterial blood.

Partial pressure of arterial CO2.

CO2 is called a “volatile acid” because it can combine reversibly with H2O to yield a strongly acidic H+ ion and a weak basic bicarbonate ion (HCO3⁻) according to the following equation:

\[ \text{CO2} + \text{H2O} \rightleftharpoons \text{H2CO3} \rightarrow \text{H}^+ + \text{HCO3}^- \]
Base Excess

- Normal range is between -2.0 to +2.0
- Indicates the level of bicarbonate.
- Negative B.E. = Base deficit = Acidosis.
- Positive B.E. = Base Excess = Alkalosis.
- Calculated value.
- The base excess is defined as the amount of H+ ions that would be required to return the pH of the blood to 7.35 if the pCO2 were adjusted to normal.

**Calculation**

Base excess = 0.93 (HCO3 - 24.4 + 14.8(pH - 7.4))
Base excess = 0.93×HCO3 + 13.77×pH - 124.58
PROTOCOL

1. Sterilize skin with alcohol.
2. Anesthetize site with 4% Lidocaine.
3. Take heparinized glass syringe.
4. Expel any residual heparin out through the needle. (The needle must be coated with heparin to prevent the formation of micro-clots).
5. Feel along the course of the radial artery and palpate for maximum pulsation with the middle and index finger. Prepare the skin with an alcohol.
6. Hold the needle at a 45-60 degree angle to the skin surface and advance into the artery.
7. Once the artery is punctured, arterial pressure will push up the hub of the syringe and a pulsating flow of blood will fill the syringe.
8. Once blood is obtained, withdraw the needle firmly and apply pressure over the site with a dry sponge.
9. Than band needle to prevent gas exchange from air. Or Block needle with rubber.
10. Transport syringe with bag of ice.
11. Continue to maintain pressure of puncture site for up to 10 minutes. (If patient is on anticoagulant medication apply pressure for 15 minutes).
The pH is a measurement of the acidity or alkalinity of the blood. It is inversely proportional to the no. of (H+) in the blood. The normal pH range is 7.35-7.45. Significant changes in the blood pH above 7.8 or below 6.8 will interfere with cellular functioning, and if uncorrected, will lead to death. Changes in body system functions that occur in an acidic state decreases the force of cardiac contractions, decreases the vascular response to catecholamines, and a diminished response to the effects and actions of certain medications. An alkalotic state interferes with tissue oxygenation and normal neurological and muscular functioning.
Acid-base Terminology

- **Acidemia**: blood pH < 7.35
- **Acidosis**: Examples:
  - Metabolic acidosis, Diabetic ketoacidosis, lactic acidosis.
  - Respiratory acidosis from hypoventilation.
  - If the patient also has an alkalosis at the same time, the resulting blood pH may be low, normal, or high.

- **Alkalemia**: blood pH > 7.45
- **Alkalosis**: Examples:
  - Metabolic alkalosis from excessive diuretic therapy;
  - Respiratory alkalosis from acute hyperventilation.
  - If the patient also has an acidosis at the same time, the resulting blood pH may be high, normal, or low.
Primary acid-base disorder:

- *Metabolic acidosis*
- *Metabolic alkalosis*
- *Respiratory acidosis*
- *Respiratory alkalosis*

- **HCO3-**
  - reduced HCO3- and acidemia
  - elevated HCO3- and alkalemia.

- **PaCO2**
  - reduced PaCO2 and alkalemia.
  - elevated PaCO2 and acidemia.
Respiratory alkalosis

- With a pH more than 7.45
- pCO2 less than 32 mmHg
- Cause
  - Hysteria, anxiety or fear.
  - Pain
  - Increased metabolic demands such as fever, sepsis, pregnancy or thyrotoxicosis.
  - Medications such as respiratory stimulants.
  - Central nervous system lesions
Metabolic alkalosis

- With a pH more than 7.45
- Bicarbonate more than 26 mEq /L
- Cause
  - Excess of base
    - Ingestion of excess antacids,
    - Excess use of bicarbonate
  - Loss of acid
    - Excessive vomiting,
    - Gastric suction,
    - Excess use of diuretics
Respiratory Acidosis

- With a pH less than 7.35
- $pCO2 > 36 \text{ mmHg}$
- Cause = due to CO2 retention
  - Asthma
  - Chronic Obstructive Pulmonary Disease
Metabolic Acidosis

- pH less than 7.35.
- Bicarbonate less than 22mEq/L

Cause:
- retention of H+ ion
- Loss of bicarbonate ion

- Renal failure
- Diabetic ketoacidosis
- Anaerobic metabolism
- Starvation
- Salicylate intoxication
## Uncompensated acid base balance

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<thead>
<tr>
<th></th>
<th>pH</th>
<th>PaCo2</th>
<th>HC03</th>
</tr>
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<tr>
<td><strong>Respiratory acidosis</strong></td>
<td>↓</td>
<td>↑</td>
<td>normal</td>
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<tr>
<td><strong>Respiratory Alkalosis</strong></td>
<td>↑</td>
<td>↓</td>
<td>normal</td>
</tr>
<tr>
<td><strong>Metabolic Acidosis</strong></td>
<td>↓</td>
<td></td>
<td>normal</td>
</tr>
<tr>
<td><strong>Metabolic Alkalosis</strong></td>
<td>↑</td>
<td></td>
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Partially compensated

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<th>paco₂</th>
<th>Hco₃</th>
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<td>↑</td>
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<tr>
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<tr>
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<tr>
<td></td>
<td>pH</td>
<td>paco2</td>
<td>Hco3</td>
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<tr>
<td>Resp. Acidosis</td>
<td>Normal</td>
<td>↑</td>
<td>↑</td>
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<tr>
<td>but &lt; 7.40</td>
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Stepwise approach to ABG

- **Step 1**: Acidemic or Alkalenic?
- **Step 2**: Is the primary disturbance respiratory or metabolic?
- **Step 3**: Assess to Pa $O_2$. A value below 80mm Hg indicates Hypoxemia. For a respiratory disturbance, determine whether it is acute or chronic.
- **Step 4**: For a metabolic acidosis, determine whether an anion gap is present.
- **Step 5**: Assess the normal compensation by the respiratory system for a metabolic disturbance.
Step 1:
Assess the pH – acidotic/alkalotic
- If above 7.5 – alkalotic
- If below 7.35 – acidotic
Step 2
Assess the paCO$_2$ level.
- pH and pCO$_2$ moves in opposite direction – Primary problem in respiratory system.
- Respiratory Acidosis
  - pH decreases below 7.35 & the paCO$_2$ should rise.
- Respiratory Alkalosis
  - pH rises above 7.45 & paCO$_2$ should fall.
Step: 2
Assess HCO₃ value

- pH & HCO₃ are moving in the same direction, primary problem is metabolic

- Metabolic Alkalosis
  - pH increases & HCO₃ also increase

- Metabolic Acidosis
  - pH decreases & HCO₃ also decrease
Step 3
Assess pO₂ < 80 mm Hg - Hypoxemia

For a respiratory disturbance: Acute or Chronic

- If the change in pCO₂ is associated with the change in pH, the disorder is acute.
- In chronic process the compensatory process brings the pH to within the clinically acceptable range (7.30 – 7.50)
Step 4  Evaluate Anion Gap

- Calculation of AG is useful approach to analyse metabolic acidosis
  \[ AG = (\text{Na}^+ + \text{K}^+) - (\text{Cl}^- + \text{HCO}_3^-) \]
- Hence there is a difference between cations and the anions.
- The unmeasured anions constitute the anion gap which is due to the presence of protein anions, sulfate, phosphate and organic acids.
- Normally this is about 10 - 12 mmol/liter.
- A change in the pH of 0.08 for each 10 mmol/L indicates an ACUTE condition.
- A change in the pH of 0.03 for each 10 mmol/L indicates a CHRONIC condition.
Analysis of simple acid-base disorders. If the compensatory responses are markedly different from those shown at the bottom of the figure, one should suspect a mixed acid-base disorder.
THANK YOU