## ARTERIAL BLOOD GAS

This is a lab test acquired from the client's arterial blood that analyzes: Oxygenation, Ventilation, Acid-base balance

### ALLEN'S TEST

Prior to obtaining an arterial blood sample from the radial artery, this procedure is performed to evaluate the radial and ulnar arteries' collateral circulation capacity. This test assesses the hand's ability to receive blood when circulation through one artery is temporarily compromised.

The client clenches a fist while pressure is applied to BOTH arteries; the client opens the hand (it should be blanched), and pressure is released from the ulnar artery. Color and temperature return is observed. If color returns within 5–15 seconds, collateral circulation is adequate and ABG may be done.

**Remember**: ABG results should never be interpreted by looking at the values alone. You should always look at how the client is actually doing.

| Parameter | Indication | Normal value |
|---|---|---|
| **pH** | Acid-base balance (determines if acidosis or alkalosis) | 7.35-7.45 |
| **PaCO2** | respiratory component (CO2 is acidic in nature) | 35-45mmHg |
| **HCO3** | metabolic component (basic in nature) | 22-26 mEq/L |
| **PaO2** | oxygenation | 80-100mmHg |
| **SaO2 (SpO2 by pulse ox)** | Hemoglobin oxygen saturation | 95-100% |

## DETERMINING ACIDITY OR ALKALINITY

**The arterial pH shows the overall hydrogen ion concentration in the blood.**

| pH | Interpretation |
|---|---|
| Less than 7.35 | ACIDIC |
| 7.35-7.45 | NORMAL |
| Greater than 7.45 | ALKALINE |

**Note: If pH is within normal range but either PaCO2 or HCO3 is abnormal, use 7.40 as reference value. Therefore <7.40 is acidic and >7.40 is alkalotic.**

> **Remember: Always begin ABG interpretation with pH value**

## PaCO2: RESPIRATORY COMPONENT

**PaCO2 shows the partial pressure of carbon dioxide in arterial blood. This functions as a respiratory component because CO2 participates in the formation of carbonic acid.**

| PaCO2 | Interpretation |
|---|---|
| Less than 35 | ALKALINE |
| 35-45 | NORMAL |
| Greater than 45 | ACIDIC |

> **Remember: The lungs regulate PaCO2 mostly through ventilation**
>
> **CO2=ACIDIC**
> **Therefore:**
> **Increased CO2: Acidosis**
> **Decreased CO2: Alkalosis**

## HCO3: METABOLIC COMPONENT

**HCO3, also known as bicarbonate, represents the primary metabolic base in the blood. It is regulated mostly by the kidneys.**

| HCO3 | Interpretation |
|---|---|
| Less than 22 | ACIDIC |
| 22-26 | NORMAL |
| Greater than 26 | ALKALINE |

> **Remember:**
> **HCO3= BASE**
> **Therefore:**
> **Increased HCO3: Alkalosis**
> **Decreased HCO3: Acidosis**

## THE 'ROME' PRINCIPLE

**Once the pH, PaCO2, and HCO3 have each been classified, the primary acid-base disorder can be determined using this principle:**

**R- Respiratory**
**O- Opposite**
**M- Metabolic**
**E- Equal**

**Respiratory - Opposite:**
**Compare pH and PaCO2:**
**If they are in opposite directions, the primary problem is respiratory.**

**Example:**
**pH- 7.26 = ↓ (Acidosis)**
**PaCO2- 47 = ↑ (Acidosis)**
**Interpretation: Respiratory Acidosis**

**Metabolic-Equal:**
**Compare pH and HCO3:**
**If they move in the same direction, the primary problem is metabolic.**

**Example:**
**pH- 7.24 ↓ (Acidosis)**
**PaCO2- 28 ↓ (Alkalosis)**
**HCO3- 12 ↓ (Acidosis)**
**Interpretation: Metabolic Acidosis**

## STEPS IN ABG INTERPRETATION:

**1st: Look at the pH value: Is it Acidosis or Alkalosis?**
**2nd: Look at the PaCO2: Determine whether the respiratory component explains the pH abnormality.**
**Remember: Respiratory Opposite**
**3rd: Look at the HCO3: Determine whether the metabolic component explains the pH abnormality.**
**Remember: Metabolic Equal**
**4th: Identify the primary disorder: Is it respiratory or metabolic?**
**5th: Assess whether the other system is responding to the primary disturbance**
**6th: Assess oxygenation: PaO2, SaO2, SpO2, and clinical respiratory status.**
**7th: Correlate with the client: The ABG should always be interpreted together with: Vital signs, respiratory assessments, LOC, Lab findings, Medical diagnosis.**

## ABG INTERPRETATION COMPENSATIONS

### COMPENSATION

**This is the body trying to bring an abnormal blood pH back toward the normal range.**

**Two major systems involved:**
**Lungs: PaCO2**
**Kidneys: HCO3**

**Remember:**
**When there is a respiratory problem, Kidneys will compensate. When there is a metabolic problem, Lungs will compensate. This is because the system that is not causing the problem tries to correct it.**

### Respiratory Disorder - Renal Compensation

**If the problem is with your lungs, the kidneys will try to correct the pH by changing HCO3.**

**Example:**
**Respiratory Acidosis**
**What happens? The client is not ventilating enough, so CO2 is retained.**

**When the kidneys detect that the blood is becoming too acidic, they compensate by retaining more $HCO3^-$ (bicarbonate), which is a base. Increasing the level of $HCO3^-$ helps neutralize the excess acid, thereby bringing the blood pH back toward normal. Therefore, if $HCO3^-$ is increased, it indicates that the kidneys are actively trying to compensate for the acidosis.**

### Metabolic Disorder- Respiratory Compensation

**If the problem is metabolic, the lungs compensate by changing ventilation and therefore PaCO2**

**Example:**

**Metabolic Acidosis**

↓ pH + ↓ HCO3- The body has too much acid or too little bicarbonate. The lungs will compensate by increasing ventilation which removes CO2. This is why metabolic acidosis can produce Kussmaul respirations.

Metabolic Acidosis → Increases ventilation as a compensatory mechanism → PaCO2 will be decreased

## DEGREE OF COMPENSATION:

The easiest way is to look at the pH first.

**UNCOMPENSATED**
The body has not started compensating

Pattern: Abnormal pH + One abnormal value+ One normal value
Example:
pH: 7.31↓
PaCO2: 56 ↑
HCO3: 23 Normal
*Interpretation: Respiratory Acidosis, Uncompensated*

**PARTIALLY COMPENSATED**
The body is compensating, but the pH is still abnormal

Pattern: Abnormal pH+ 2 values abnormal
Example:
pH: 7.30 ↓ Acidosis
PaCO2: 60 ↑ Acidosis
HCO3: 29 ↑ kidneys are compensating
*Interpretation: Respiratory Acidosis, Partially Compensated*

**FULLY COMPENSATED**
The body has compensated enough to bring the pH back into the normal range

Pattern: Normal pH+ Abnormal PaCO2+ Abnormal HCO3
pH = 7.39 Normal but on acidic side
$PaCO_2$ = 50 ↑
$HCO_3^-$ = 30 ↑
*Interpretation: Respiratory Acidosis, Fully compensated.*

## ABG AND POTASSIUM

Acid-base disturbances may produce shifts in serum potassium.

**Acidosis**
Hydrogen ions shift into cells, while potassium may shift out. Therefore, when client experiences acidosis, the serum potassium level may increase.

**Alkalosis**
Potassium may shift into cells. Therefore, when client experiences alkalosis, the serum potassium level may decrease.

| Imbalance | Causes | Manifestations | Interventions |
|---|---|---|---|
| Respiratory Acidosis | Severe asthma<br>Obstructed Airway<br>COPD<br>Sedative/Opioid overdose<br>Neuromuscular disorders<br>Depression of CNS<br>Inadequate mechanical ventilation | Headache<br>Confusion<br>Drowsiness<br>Decreased LOC<br>Respiratory depression | • Assess airway and respiratory status.<br>• Keep the airway patent.<br>• Promote adequate ventilation.<br>• Administer oxygen as needed<br>• Treat the underlying cause<br>• Monitor ABGs and clinical response |
| Respiratory Alkalosis | Anxiety/ Panic attack<br>Pain<br>Fever<br>Hypoxemia<br>High altitude<br>Mechanical over-ventilation<br>Early salicylate toxicity | Lightheadedness<br>Dizziness<br>Numbness/Tingling<br>Muscle cramps<br>Confusion | • Identify the reason behind the hyperventilation. Don't always assume that anxiety is the reason.<br>• Evaluate respiratory health and oxygenation.<br>• Treat underlying cause. If the reason is anxiety, reassure the client and coach slow, controlled breathing.<br><br>Remember: Asking a client who is hyperventilating to breathe into a brown paper bag should not be done on a regular basis as hyperventilation may also be caused by hypoxemia or a life-threatening illness—not only respiratory acidosis. |

| | | | |
|---|---|---|---|
| Metabolic Acidosis | Diabetic ketoacidosis<br>Severe diarrhea<br>Lactic acidosis<br>Shock<br>Renal failure<br>Bicarbonate loss<br>Certain toxic ingestions | Deep, rapid respirations /Kussmaul respiration<br>Weakness<br>N&V<br>Confusion<br>Decreased LOC<br>Dysrhythmias | • Assess respiratory status: Monitor for deep, rapid respirations/Kussmaul respirations<br>• Identify and treat the underlying cause<br>• Monitor potassium closely: Particularly in DKA<br>• Monitor fluid status |
| Metabolic Alkalosis | Prolonged vomiting<br>Nasogastric suction<br>Diuretic therapy<br>Excess bicarbonate administration<br>Hypokalemia<br><br>**Remember**: Vomiting -> loss of gastric acid -> metabolic alkalosis | Weakness<br>Confusion<br>Muscle cramps<br>Dysrhythmias<br>Hypoventilation<br>Paresthesia<br>Manifestations of hypokalemia | • Identify and treat underlying cause.<br>• Monitor electrolytes particularly K and Cl<br>• Monitor cardiac rhythm when indicated: Hypokalemia increases the risk of cardiac dysrhythmias<br>• Correct fluid and electrolyte abnormalities<br>• Manage ongoing gastrointestinal loss<br>• Monitor respiratory status: Respiratory compensation may result in hypoventilation and Increased $PaCO_2$ |