Arterial Blood Gas
Interpretation for the
Bedside Nurse

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Objectives

• Identify three essential components of the ABG series
• Relate ABG results to potential interventions in specific patient scenarios

Introduction

• Arterial Blood Gas (ABG) Overview
  – Drawn from arterial source- radial (most often used), brachial, and femoral
  – Helpful in identifying respiratory/oxygenation deficiencies and metabolic/acid-base balance deficiencies
  – Critical care patients may have arterial line placed for frequent draws
Acid/Base Regulation Review

• Buffering
  – Normal body mechanism that occurs rapidly in response to acid-base disturbances to prevent changes in H+ concentration.
  • Respiratory: regulates the excretion or retention of carbonic acid. Fast response, usually within minutes but response is weak.
    – If pH decreases, the rate and depth of breathing increases.
    – If pH increases, the rate and depth of breathing decreases.
  • Renal System: regulates the excretion and retention of bicarb (HCO₃). Slower response, usually about 48 hours but a powerful result.
    – If pH decreases, the kidney will retain HCO₃.
    – If pH increases, the kidney will release HCO₃.

Knowledge Gap

• Youssef, et al. (2013) indicated gap between nurses’ knowledge and practices as compared to the evidence-based guidelines of American Association of Respiratory Care in management of ABG sampling.
• Recommendations were to enrich nursing knowledge and practices related to:
  – ABG indications, sampling practices, complications of sampling and...
  • Interpretation of Parameters

ABG COMPONENTS

- pH
- PO₂
- SaO₂
- PCO₂
- HCO₃
- BE
pH

- Measurement of acidity or alkalinity, based on hydrogen (H⁺) ions.
- **Normal is 7.35-7.45**
  - Increase in H⁺ = lower pH, more acidic
  - Decrease in H⁺ = higher pH, more alkaline

PO₂

- The partial pressure of oxygen that is dissolved in arterial blood. Reflection of alveolar ventilation.
- ↑ PO₂ = hypoventilation is present
- ↓ PO₂ = hyperventilation is present
- Normal = adequate ventilation

SaO₂

- Oxygenation
  - Process by which oxygen enters the bloodstream via the lungs. Reflects saturation of hemoglobin with oxygen.
  - Oxygenation dependent factors:
    - Atmospheric pressure
    - Fraction of oxygen in inspired air
    - Movement of oxygen into the lungs (ventilation)
    - Adequate blood flow to pulmonary capillaries (perfusion)
    - Movement of oxygen across the alveolar-capillary membrane
- Any problems with one or more factors will cause inadequate oxygenation of the blood = ↓ SaO₂ or hypoxemia
- **Normal range is 95-100%**
**PCO₂**

- Partial pressure of carbon dioxide dissolved in arterial blood.
- Normal is 35-45 mmHg

**HCO₃**

- The calculated value of bicarbonate in the bloodstream.
- Normal is 22-26 mmol/L

**Base Excess (BE)/Deficit**

- The base excess/deficit indicates the amount of excess or insufficient level of bicarbonate in the system.
- Negative base level is reported as a deficit and associated with metabolic acidosis
- Positive base level is reported as excess and associated with metabolic alkalosis
- Normal is -2 to +2 mEq/L
Normal ABG values

- **pH**: 7.35-7.45
- **PCO₂**: 35-45 mmHg
- **PO₂**: 80 - 100 mmHg
- **HCO₃⁻**: 22-26 mmol/L
- **BE**: -2 to +2
- **SaO₂**: >95%

**ABG Interpretation**

- The only two ways an acidotic state can exist is from too much CO₂ or too little HCO₃⁻.
- The only two ways an alkalotic state can exist is too little CO₂ or too much HCO₃⁻.

So the key is finding what KIND of acidotic or alkalotic state the patient is in: respiratory or metabolic! Figuring out what kind will then guide your treatment!

**Interpretation Methods**

1. Stepwise approach
2. “Tic-tac-toe” method
3. Color Method
1. Stepwise Approach

- Step 1: Determine the pH (acidosis or alkalosis)
- Step 2: Evaluate PCO₂
  - Too much/too little acid?
    - (>45 = acidosis or <35 = alkalosis)
- Step 3: Evaluate HCO₃⁻
  - (>26 = alkalosis or <22 = acidosis)
- Step 4: Matching!
  - Match the “problem” value with the pH

Practice: pH 7.24, PCO₂ 75, HCO₃⁻ 28

\[\begin{array}{c|c|c}
\text{acidic} & \uparrow & \text{normal} \\
\end{array}\]

2. Tic-Tac-Toe Method

- In order to use the tic-tac-toe method you must first get a sheet of paper and set up a “tic-tac-toe” grid. Then label each “column” as “acid”, “normal”, and “base”. It should look like this:

\[\begin{array}{c|c|c}
\text{Acid} & \text{Normal} & \text{Base} \\
\end{array}\]

Practice ABG:

- pH 7.24, PCO₂ 75, HCO₃⁻ 28

1. Draw your tic-tac-toe layout.
2. Analyze your pH. Ask yourself if it is normal, basic, or acidic? Since the pH is less than 7.35 making it an acid, place it under the acid column.
3. Analyze your PCO₂. Ask yourself if it is normal, basic, or acidic? Since the PCO₂ is greater than 45 making it an acid, place it under the acid column along with pH. Remember PCO₂ is the opposite and the normal is 35-45.
4. Analyze your HCO₃⁻. Ask yourself if it is normal, basic, or acidic? Since HCO₃⁻ is greater than 26 making it basic, place it under the base column because the value is considered basic.

- Layout should look like this:
3. Color Method

- **Blue** = base
- **Red** = acid
- **Black** = neutral

**Practice ABG:**
- pH 7.24, PCO₂ 75, HCO₃ 28

Now find the parameter color that matches the pH...

Respiratory Acidosis

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**ABG ALTERATIONS**

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**Case Study #1**

- A 55 year old male is found down in a hospital waiting area. EMS is called and upon arrival, the patient is found to have an oxygen saturation of 88% and pinpoint pupils.
- He is brought to your ER where a room air arterial blood gas is performed.
- Results: pH 7.25, PCO₂ 60, PO₂ 65, HCO₃ 26
- Acid-base status: ____________?
Respiratory Acidosis

- Hypoventilation caused by any of the following:
  - COPD, Sleep apnea, or other lung diseases that result in decreased excretion of CO₂
  - Over-sedation, head trauma, anesthesia, and drug overdose
  - Neuromuscular disorders like Guillain-Barre
  - Pneumothorax, flail chest or other chest wall trauma interfering with breathing mechanics
  - Inappropriate ventilator settings
- Treatment: Improvement of ventilation
  - Supplemental O₂, Administration of reversal agents, change in ventilator settings

Case Study #2

- A 72 year old female presents with 2 days of fever, dyspnea, and productive cough. Her room air oxygen saturation is 85% and a room air ABG is obtained while waiting for portable chest X-ray.
- Results: pH 7.54  PCO₂ 25  PO₂ 65  HCO₃ 22
- Acid-base status: ____________?

Respiratory Alkalosis

- Excess CO₂ exhaled (hyperventilation) caused by any of the following:
  - Anxiety/nervousness
  - Hypoxemia or interstitial lung disease
  - Pulmonary embolus, pulmonary edema
  - Bacteremia (sepsis), liver disease, or fever
- Treatment:
  - Treat underlying cause
  - Slow respiratory rate
Case Study #3

- A 45 year old lawyer is brought to the hospital with complaints of severe nausea and weakness. He has had problems with peptic ulcer disease in the past and has been having similar pain for the past 2 weeks. Room air ABG is drawn.
- Results: pH 7.46 PCO₂ 45 PO₂ 68 HCO₃ 34
- Acid-base status: ____________?

Metabolic Acidosis

- pH + ↓ HCO₃

  - Bicarbonate loss at a rate exceeding capacity of kidneys to restore caused by:
    - Severe dehydration, leading to hyperchloremic acidosis caused by the loss of too much sodium bicarbonate from the body (associated with Diabetic ketoacidosis)
    - Lactic Acidosis caused by: Alcohol, cancer, liver failure, hypoglycemia, aspirin, seizures, shock states
    - Kidney disease
    - Poisoning by methanol, ethylene glycol (found in antifreeze), or methanol
    - Administration of Hyperalimentation
    - Rapid IV infusion of non-bicarb containing solutions which produces a dilutional acidosis

  - Treatment:
    - Treat underlying cause
    - Administration of Sodium Bicarbonate either by IV push or IV infusion

Case Study #4

- A 24 year old male presents with a two-day history of severe abdominal pain, nausea, and vomiting. On exam, his blood pressure is 90/50 and he has a markedly tender epigastrium. Room air ABG is drawn.
- Results: pH 7.32 PCO₂ 35 PO₂ 88 HCO₃ 16
- Acid-base status: ____________?
Metabolic Alkalosis

\[ \text{↑pH + ↑HCO}_3^- \]

- Elevated bicarbonate level related to:
  - Chloride depletion: vomiting, prolonged NG suctioning, diuretic use
  - Hypokalemic alkalosis: caused by the kidneys’ response to an extreme lack or loss of potassium, which can occur when people take certain diuretic medications.
  - Excessive alkali intake, such as antacid abuse, massive blood transfusion containing citrate

- Treatment:
  - Treat underlying cause
  - Administration of potassium/chloride replacement along with IV fluid administration

Acid/Base Mnemonic (ROME)

- Respiratory: Opposite
  - \[ \text{↓pH + ↓CO}_2 \] Acidosis
  - \[ \text{↑pH + ↑CO}_2 \] Alkalosis

- Metabolic: Equal
  - \[ \text{↓pH + ↓HCO}_3^- \] Acidosis
  - \[ \text{↑pH + ↑HCO}_3^- \] Alkalosis

Acid-Base Compensation

- Respiratory disturbances will result in kidney compensation:
  - Resp Acidosis
    - Increase acid excretion
    - Increase bicarb reabsorption
      - Slow process
  - Resp Alkalosis
    - Increase bicarb excretion
      - Slow process
• Metabolic disturbances result in pulmonary compensation:
  – **Metabolic Acidosis**
    • Hyperventilation to decrease PCO2
      – Rapid compensation!
  – **Metabolic Alkalosis**
    • Hypoventilation
      – Rapid compensation

**ABGs – Interpreting Compensation**

- pH of 7.40 is used as "normal" when BOTH the pCO2 and HCO3 are abnormal.
- 7.35 – 7.45
  - So, 7.38 is now considered acidosis. In order to determine if the abnormality is due to the kidneys (metabolic) or lungs (respiratory) find the 2 matching values.
  - The match reveals the method of compensation.

<table>
<thead>
<tr>
<th>High pH</th>
<th>Low pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkalosis</td>
<td>Acidosis</td>
</tr>
<tr>
<td>PaCO2</td>
<td>PaCO2</td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
</tr>
</tbody>
</table>

- Ex. pH 7.38 (7.40) Acidosis
  - PaCO2 56 (35-45) Acidosis-lungs
  - HCO3 35 (22-26) Alkalosis

**Using Technology in Interpretation**

- Graphical ABG visualization
  - Shown improvement in accuracy of identification
  - Decreased response times when using graphical visualization
  - "Visualization may help nurses during high-stress situations when decisions must be made quickly" (Doig, 2011)
Putting It Into Practice

• ABGs contain valuable information but does not replace a thorough patient assessment!
• Be systematic with your analysis!
• Practice, practice, practice!

References


PRACTICE ABG’S

*To work on your own. Answers on last slide.
#1
- pH 7.52
- pCO$_2$ 55
- pO$_2$ 92
- HCO$_3$ 42
- BE 17

#2
- pH 7.15
- pCO$_2$ 22
- pO$_2$ 92
- HCO$_3$ 9
- BE -30

#3
- pH 7.10
- pCO$_2$ 60
- pO$_2$ 125
- HCO$_3$ 22
- BE -15
#4
- pH 7.44
- pCO$_2$ 25
- pO$_2$ 60
- HCO$_3$ 22
- BE -7

#5
- pH 7.36
- pCO$_2$ 33
- pO$_2$ 55
- HCO$_3$ 18
- BE -5

Answers
1. Metabolic alkalosis
2. Metabolic acidosis
3. Respiratory acidosis
4. Compensated respiratory alkalosis
5. Compensated metabolic acidosis