ABG Interpretation and Significance

ABGs are the primary method for evaluating oxygenation/ventilation and acid-base status. However they do have some limitations: they only provide info for one point in time, you must compare prior results, there are influencing factors, and you have to consider the patient's clinical condition...so I guess what this means is it's not easy?

Clinical indications for drawing an ABG:
• A change in LOC
• Increasing respiratory difficulty
• Low blood pressure (70s, 80s?)

Components of the ABG:
• PaO2: The partial pressure of oxygen dissolved in plasma. The PaO2 measures oxygenation, and normal ranges are 80-100 mm Hg. ALWAYS look at the PaO2 FIRST! Your pt may need urgent oxygenation, and you don’t want to wait around while you diddle around with interpreting the entire ABG.
• pH: This is a measure of the overall concentration of Hydrogen ions...it measures acid/base in the blood. Normal range is 7.35 - 7.45
• PaCO2: This is the partial pressure of carbon dioxide dissolved in plasma. It measures ventilation (how well the body can get rid of CO2)...it is the respiratory component of the ABG. Normal is 35-45 mm Hg.
• HCO3-: This is bicarbonate, a chemical buffer made in the kidneys to neutralize acids. It is the metabolic component of the ABG. Normal is 22-28 mEq/L.
• SaO2: This is a measure of the % of oxygen that is attached to hemoglobin in red blood cells. Normal is > 95% in healthy humans (avg is 98% for a healthy pt).
• Base Excess: This is an indicator of the total buffer base of the body. It ranges from -2mEq to +2mEq. If you have a LOT of base, the base excess level moves toward the positive side. If you don’t have a lot of base excess, it will move toward the negative side. When the pt is in acidosis, the level will be more negative. This is essentially an overview of what is happening with acid/base balance in the body.

Oxygenation Assessment
There are several factors that affect O2 delivery:
• Cardiac output
• Hemoglobin
• Arterial O2 saturation
• Affinity of hemoglobin for O2 (oxyhemoglobin disassociation curve). Recall from your A&P that a shift to the right means the RBCs are going to be unloading their O2 more readily (so a reduced affinity for oxygen). A shift to the left means the RBCs are going to hold on to the O2 more fiercely and participate in less unloading (a greater affinity for oxygen). In acidotic states, this is a shift to the RIGHT, so if a pt is mildly acidotic the MD may leave them there for a bit because it improves O2 delivery.

Demand vs. Extraction
Normal extraction is 25% of available O2. As the blood goes around the vascular system, 25% of the oxygen is extracted in one trip. Increased O2 demand (increased metabolic needs) results in increased extraction. This is measured as the SVO2 (Saturation of Venous Oxygen). This sample is drawn from the right side of the heart.
• Normal values are 72-75%.
• A low value means you have increased extraction and increased need. You will need to give oxygen and blood to this patient.
• A high value means the tissues are unable to extract...you need to find out why. There could be a clot in microcirculation (this happens in sepsis.) There could also be toxins in the blood (sepsis) or an alkalotic state (recall that alkalosis causes the curve to shift to the left).
• Common factors affecting O2 demand:
  • Increased metabolic activity (fever, infection, ADLs)
  • Increased WOB
  • Pain/Anxiety

PaO2 in the older adult:
The PaO2 will be lower in the older adult due to lung changes that occur with aging. The formula for estimating this is 80 - # of years over 60 = lower limit PaO2. Note that a bit of mild hypoxemia is normal for an older adult...the levels probably shouldn’t be lower than 60 though, despite the formula.

Acid-Base Balance Assessment
pH is inversely related to the concentration of hydrogen ions in the blood. When hydrogen ions are high, this equates to a low pH (acidosis). When hydrogen ions are low, this equates to a high pH (alkalosis).

Regulation of Acids and Bases
The acid/base balance in the body is regulated by the respiratory system and the renal system. The respiratory system is responsible for altering CO2 levels in the body to balance pH. Chemo receptors sense pH changes and increase or decrease the respiratory rate and depth. This change occurs within minutes of pH alterations. REMEMBER....on the ABG, the PaCO2 is an acid!!!

The renal system will work to compensate a respiratory imbalance via the production of bicarbonate. The kidneys also reabsorb or excrete acids and bases and is a major buffer system. However, the renal system takes hours or days to kick in and achieve compensation. When looking at the renal system, you want to look at the bicarb AND the serum carbon dioxide (which is not the same as the "gas" CO2). This measurement of the serum CO2 reflects the buffering status of the kidneys. When the serum CO2 is low, this means bicarbonate is being used up to buffer acids. In other words, a low level reflects a metabolic acidosis. If you received information from your Chem 7 or Chem 20 that the serum CO2 on your patient is low, there is acid in the body that needs to be buffered...you will want to get an ABG stat! Normal levels for the serum CO2 are 24-30...you will call the MD for levels < 20.

The Buffering System
In addition to acid and bicarb (as you can see on the right), the body also has phosphate buffers and protein buffers that act within seconds to protect tissues and cells from abnormal pH. Proteins are the most plentiful buffers in the body!
### Respiratory Acidosis (↓pH and ↑PaCO₂)

| ABG:       | pH < 7.35  
| PaCO₂ > 45 mm Hg | Signs:          | Early: headache, fatigue, flushed skin, irritability  
|            |            | Late: lethargy, confusion, somnolence  
| Mech:      | Hypoventilation | Tx:                | -Breathe more! (Increase RR)  
|            |            | -Treat the cause (reverse narcs prn with Narcan/Romazicon)  
|            |            | -Improve respiratory efforts (use IS, ↑mobility, positioning, C/DB, bronchodilators, correct vent settings/rate  
|            |            | -Continually reassess  
| Causes:    | drugs, head injury, lung disease, airway obstruction, respiratory muscle dysfxn, chest wall dysfxn. | Goal: | Decrease CO2 levels  
|            |            | Provide adequate O2  
|            |            | Normal pH  

### Respiratory Alkalosis (↑pH and ↓PaCO₂)

| ABG:       | pH > 7.45  
| PaCO₂ < 35 mm Hg | Signs:          | Initially: anxiety, increased irritability of CNS and peripheral NS  
|            |            | Goal: | Increase CO2 levels  
|            |            | Provide adequate O2  
|            |            | Normal pH  
| Mech:      | Hyperventilation | Tx:                | -Address the underlying cause (pain, anxiety)  
|            |            | -Help pt calm down and breathe slower  
|            |            | -Lower the rate or volume on vent settings  
| Causes:    | stimulated respiratory system, arterial hypoxemia, increased metabolism, hepatic failure that is putting a lot of ammonia in the system, mechanical ventilation (problem with rate or volume), CNS provlems | Goal: | Normal pH  

### Metabolic Acidosis (↓pH and ↓HCO₃⁻)

| ABG: | pH < 7.45  
HCO₃⁻ < 22 mEq/L | Signs: | -CNS depression, HA, weakness, confusion  
-Later you’ll have dilirium then stupor  
-Respiratory depression  
-Kussmaul respirations |
| Mech: | loss of base or gain of acid | Tx: | -Treat the underlying problem  
-Replace bicarb  
-Monitor K⁺ (K⁺ will come out of the cell and go into the cell with fluctuations in acid) |
| Causes: | -Lose base: losses of bile, pancreatic juices, small intestine secretions containing bicarb (fistulas, diarrhea).  
-Gain acid: ketoacidosis, lactic acidosis (occurs with sepsis), drugs, poisons, TPN  
-Renal failure (decreased secretion of H⁺ ions, so more H⁺ retained) | Goal: | Increase bicarb levels  
Normal pH  
Normal serum electrolytes |

### Metabolic Alkalosis (↑pH and ↑HCO₃⁻)

| ABG: | pH > 7.45  
HCO₃⁻ > 28 mEq/L | Signs: | -Irritability of central and peripheral NS  
-Cramps  
-Tetany  
-Dizziness  
-Disorientation → lethargy |
| Mech: | gain of base or loss of acid | Tx: | -Remove source (decrease antacids)  
-Monitor electrolytes (K⁺)  
-Treat cause (vomiting) |
| Causes: | -Diuretics (gain of base)  
-Excessive antacids (gain of base)  
-mineralocorticoids  
-GI output (loss of acid via vomiting and gastric sxn...intermittent sxn is better!) | Goal: | Lower bicarb levels  
Normal pH  
Normal serum electrolytes |
Mixed Acid Base Balances
This happens when you’ve got two or more primary abnormalities. An example of this would be an acidic CO2, an acidic pH, and an acidic bicarb. This would be a respiratory AND metabolic acidosis.

Reading the ABG
Step 1: Look at the PaO2. If the oxygen is < 80 mmHg, give your pt some O2 STAT! The exception would be if they are a COPD pt or an older adult. For moderate hypoxemia (50-59) call the physician STAT. For severe hypoxemia (20-49), call the MD and anticipate intubation. When considering the oxygen source for your patient, you want to use a NC if you can get away with it (“high flow” NC can go up to 8). Next option is the 100% NRB, next is BiPAP, and last is intubate.

Step 2: Look at the pH to assess acid-base status.
- 7.40 is normal pH
- 7.35-7.45 is the normal range for pH
- pH < 7.35 is acidosis
- pH > 7.5 is alkalosis
- Consider the “lean” when necessary:
  - pH 7.35 to 7.39 is “leaning” to acidosis
  - pH 7.41-7.45 is “leaning” to alkalosis

Step 3: Look at the PaCO2.
- Normal: 35-45 mmHg
- Acidosis: > 45 mmHg
- Alkalosis: < 35 mmHg
Next, you will want to ask yourself if the PaCO2 matches the pH...are they both acidotic or both alkalotic? If so, your primary problem is a respiratory problem!

Step 4: Look at the HCO3-
- Normal: 22 - 28 mEq/L
- Acidosis: < 22
- Alkalosis: > 28
Ask yourself if the bicarb matches the pH. If they are both acid or both alkaline then your primary problem is a metabolic problem. Isn't this fun?

Step 5: Determine the extent of compensation
- Uncompensated (2 abnormal and 1 normal)
  - The pH is abnormal
  - The component that matches the pH (either acidic or alkalotic) is also abnormal
  - The component that does NOT match the pH is normal...it is not helping out!
  - Ex: PaO2 90 (normal), pH 7.51 (alk), PaCO2 30 (alk), HCO3 25 (normal)
    - In the above example, the problem is uncompensated respiratory alkalosis.
- Partial compensation (3 abnormal)
  - pH is abnormal
  - The component that matches the pH is also abnormal
  - The component that does not match the pH is also abnormal
  - Ex: PaO2 40 (way too low!), pH 7.15 (acid), PaCO2 76 (acid), HCO3 32 (alk).
    - This is partially compensated respiratory acidosis
- Fully compensated (pH will be normal, all others abnormal)
  - pH is normal
• Component that matches the “pH lean” is abnormal
• Component that does not match the “pH lean” is abnormal
• Ex: PaO2 93 (fine), pH 7.35 (acid lean), PaCO2 28 (alk), HCO3 14 (acid)
  • This is compensated metabolic acidosis

REFERENCES


