

## 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?)

### **Practice Alert!**

If the pH is altered, meds that used to work may not in this acidic/alkalotic environment. That would be a double-whammy for your pt!

Components of the ABG:

- **PaO<sub>2</sub>**: The partial pressure of oxygen dissolved in plasma. The PaO<sub>2</sub> measures oxygenation, and normal ranges are **80-100 mm Hg**. ALWAYS look at the PaO<sub>2</sub> 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**
- **PaCO<sub>2</sub>**: This is the partial pressure of carbon dioxide dissolved in plasma. It measures ventilation (how well the body can get rid of CO<sub>2</sub>)...it is the respiratory component of the ABG. Normal is **35-45 mm Hg**.
- **HCO<sub>3</sub><sup>-</sup>**: 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**.
- **SaO<sub>2</sub>**: 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 O<sub>2</sub> delivery:

- Cardiac output
- Hemoglobin
- Arterial O<sub>2</sub> saturation
- Affinity of hemoglobin for O<sub>2</sub> (oxyhemoglobin disassociation curve). Recall from your A&P, that a shift to the right means the RBCs are going to be unloading their O<sub>2</sub> more readily (so a reduced affinity for oxygen). A shift to the left means the RBCs are going to hold on to the O<sub>2</sub> 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 O<sub>2</sub> delivery.

## Demand vs. Extraction

Normal extraction is 25% of available O<sub>2</sub>. As the blood goes around the vascular system, 25% of the oxygen is extracted in one trip. Increased O<sub>2</sub> demand (increased metabolic needs) results in increased extraction. This is measured as the SVO<sub>2</sub> (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 O<sub>2</sub> demand:
  - Increased metabolic activity (fever, infection, ADLs)
  - Increased WOB
  - Pain/Anxiety

PaO<sub>2</sub> in the older adult:

The PaO<sub>2</sub> 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 PaO<sub>2</sub>. 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 CO<sub>2</sub> 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 PaCO<sub>2</sub> 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" CO<sub>2</sub>). This measurement of the serum CO<sub>2</sub> reflects the buffering status of the kidneys. When the serum CO<sub>2</sub> 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 CO<sub>2</sub> 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 CO<sub>2</sub> 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!

### Levels of Hypoxemia (PaO<sub>2</sub>)

80-100 mm Hg = normal  
 60-79 mm Hg = mild hypoxemia  
 50-59 mm Hg = moderate hypoxemia  
 20-49 mm Hg = severe hypoxemia....MOVE FAST!

Hypoxemia = low O<sub>2</sub> in blood  
 Hypoxia = low O<sub>2</sub> in tissues  
 SaO<sub>2</sub> > 95% in healthy lungs  
 SaO<sub>2</sub> > 90% in COPD



### Respiratory Acidosis ( $\downarrow$ pH and $\uparrow$ PaCO<sub>2</sub>)

ABG:	pH < 7.35 PaCO <sub>2</sub> > 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, $\uparrow$ 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 CO <sub>2</sub> levels Provide adequate O <sub>2</sub> Normal pH

### Respiratory Alkalosis ( $\uparrow$ pH and $\downarrow$ PaCO<sub>2</sub>)

ABG:	pH > 7.45 PaCO <sub>2</sub> < 35 mm Hg	Signs:	Initially: anxiety, increased irritability of CNS and peripheral NS
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 problems	Goal:	Increase CO <sub>2</sub> levels Provide adequate O <sub>2</sub> Normal pH

### Metabolic Acidosis ( $\downarrow$ pH and $\downarrow$ HCO<sub>3</sub><sup>-</sup>)

ABG:	pH < 7.45 HCO <sub>3</sub> <sup>-</sup> < 22 mEq/L	Signs:	-CNS depression, HA, weakness, confusion -Later you'll have delirium then stupor -Respiratory depression -Kussmaul respirations
Mech:	loss of base or gain of acid	Tx:	-Treat the underlying problem -Replace bicarb -Monitor K <sup>+</sup> (K <sup>+</sup> 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 <sup>+</sup> ions, so more H <sup>+</sup> retained)	Goal:	Increase bicarb levels Normal pH Normal serum electrolytes

### Metabolic Alkalosis ( $\uparrow$ pH and $\uparrow$ HCO<sub>3</sub><sup>-</sup>)

ABG:	pH > 7.45 HCO <sub>3</sub> <sup>-</sup> > 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 <sup>+</sup> ) -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 CO<sub>2</sub>, an acidic pH, and an acidic bicarb. This would be a respiratory AND metabolic acidosis.

## Reading the ABG

**Step 1:** Look at the PaO<sub>2</sub>. If the oxygen is < 80 mmHg, give your pt some O<sub>2</sub> 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 PaCO<sub>2</sub>.

- Normal: 35-45 mmHg
- Acidosis: > 45 mmHg
- Alkalosis: < 35 mmHg

Next, you will want to ask yourself if the PaCO<sub>2</sub> matches the pH...are they both acidotic or both alkalotic? If so, then your primary problem is a respiratory problem!

**Step 4:** Look at the HCO<sub>3</sub><sup>-</sup>

- 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: PaO<sub>2</sub> 90 (normal), pH 7.51 (alk), PaCO<sub>2</sub> 30 (alk), HCO<sub>3</sub> 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: PaO<sub>2</sub> 40 (way too low!), pH 7.15 (acid), PaCO<sub>2</sub> 76 (acid), HCO<sub>3</sub> 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: PaO<sub>2</sub> 93 (fine), pH 7.35 (acid lean), PaCO<sub>2</sub> 28 (alk), HCO<sub>3</sub> 14 (acid)
  - This is compensated metabolic acidosis

#### REFERENCES

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