

6 Easy Steps to ABG Analysis

E-Booklet

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WELCOME TO THE 6 EASY STEPS TO ABG ANALYSIS!

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Nurses often have difficulty interpreting arterial blood gases (ABGs). Confusion often begins with trying to remember many random rules and lacking a standardized approach to ABGs. In addition, nurses often attempt to analyze too many components of the ABG at the same time. The result is often confusion and an incorrect diagnosis.

Therefore, the “6 Easy Steps to ABG Analysis” were developed to provide nurses with an accurate and systematic method of easily interpreting arterial blood gases.

The “6 Easy Steps to ABG Analysis” are listed below for easy reference, and will be explained in more detail in the sections that follow. Lastly, examples will be presented with a systematic review of pertinent findings.

The 6 Easy Steps to ABG Analysis:

1. Is the pH normal?
2. Is the CO₂ normal?
3. Is the HCO₃ normal?
4. Match the CO₂ or the HCO₃ with the pH
5. Does the CO₂ or the HCO₃ go the opposite direction of the pH?
6. Are the pO₂ and the O₂ saturation normal?

In order for our analysis to be effective, notes will have to be written next to the results on our lab slip. Alternately, the ABG results can be transcribed onto another paper for analysis (see example one below for the format).

Step 1: Analyze the pH

The first step in analyzing ABGs is to look at the pH. Normal blood pH is 7.4, plus or minus 0.05, forming the range 7.35 to 7.45. If blood pH falls below 7.35 it is acidic. If blood pH rises above 7.45, it is alkalotic. If it falls into the normal range, label what side of 7.4 it falls on. Lower than 7.4 is normal/acidic, higher than 7.4 is normal/alkalotic. Label it.

Step2: Analyze the CO2

The second step is to examine the pCO₂. Normal pCO₂ levels are 35-45mmHg. Below 35 is alkalotic, above 45 is acidic. Label it.

Step 3: Analyze the HCO3

The third step is to look at the HCO₃ level. A normal HCO₃ level is 22-26 mEq/L. If the HCO₃ is below 22, the patient is acidotic. If the HCO₃ is above 26, the patient is alkalotic. Label it.

Step 4: Match the CO2 or the HCO3 with the pH

Next match either the pCO₂ or the HCO₃ with the pH to determine the acid-base disorder. For example, if the pH is acidotic, and the CO₂ is acidotic, then the acid-base disturbance is being caused by the respiratory system. Therefore, we call it a respiratory acidosis. However, if the pH is alkalotic and the HCO₃ is alkalotic, the acid-base disturbance is being caused by the metabolic (or renal) system. Therefore, it will be a metabolic alkalosis.

Step 5: Does the CO2 or HCO3 go the opposite direction of the pH?

Fifth, does either the CO₂ or HCO₃ go in the opposite direction of the pH? If so, there is compensation by that system. For example, the pH is acidotic, the CO₂ is acidotic, and the HCO₃ is alkalotic. The CO₂ matches the pH making the primary acid-base disorder respiratory acidosis. The HCO₃ is opposite of the pH and would be evidence of compensation from the metabolic system.

Step 6: Analyze the pO2 and the O2 saturation.

Finally, evaluate the PaO₂ and O₂ sat. If they are below normal there is evidence of hypoxemia.

Normal Values (At sea level): Range:

pH	7.35-7.45
pCO ₂	35-45 mmHg
pO ₂	80-100 mmHg
O ₂ Saturation	95-100%
HCO ₃ ⁻	22-26 mEq/L
Base Excess	+ or - 2

6 Easy Steps to ABG Analysis

A STEP-BY-STEP METHOD FOR ANALYZING ABGS:

1. Is the pH out of range?
2. Secondly, is the pCO₂ normal?
3. Thirdly, is the HCO₃ out of range?
4. Next, match the abnormal result with the pH.
5. Fifth, does the PaCO₂ or HCO₃ go in the opposite direction of the pH?
6. Lastly, is the pO₂ and O₂ saturation out of range?

Reference Ranges:

pH	7.35-7.45
pCO₂	35-45 mmHg
HCO₃	22-26 mEq/L
pO₂	80-100 mmHg
O₂ Sat.	95-100%

Anion Gap

AG = Na⁺ + K⁺ - (Cl⁻ + HCO₃⁻)
 (Major cations - major anions)
 Normal = 10-15 mEq/L

Compensation:

Compensation occurs to maintain acid/base balance. Compensation will always be from the opposing system. If the pH remains abnormal, the compensation is partial. If the pH returns to normal, the compensation is complete.

System causing imbal.	Compensating system
Respiratory (pCO ₂)	Metabolic (HCO ₃)
Metabolic (HCO ₃)	Respiratory (pCO ₂)

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LOOK AT THE CHART BELOW TO DETERMINE THE EVALUATION OF ABNORMAL VALUES:

Test	Normal	↓ Value	↑ Value
pH	7.35-7.45	Acidosis	Alkalosis
pCO ₂	35-45	Alkalosis	Acidosis
HCO ₃	22-26	Acidosis	Alkalosis
pO ₂	80-100	Hypoxemia	O ₂ Therapy
SaO ₂	95-100%	Hypoxemia	————

Notice that if the pH is lower than 7.35 it indicates acidosis, if the pH is higher than 7.45 it indicates alkalosis. The HCO₃ is also acidotic if it is low: less than 22 indicates acidosis. If the HCO₃ is higher than 26 it indicates alkalosis. However, if the CO₂ is lower than 35 it indicates alkalosis, and if the CO₂ is higher than 45 it indicates acidosis.

One way to remember this relationship is to use the acronym **ROME**.

Respiratory Opposite

Metabolic Equal

The CO₂ is the respiratory component of the ABG, and if it is low and the pH is high the patient would have a respiratory alkalosis. They move in *opposite* directions to match.

The HCO₃ is the metabolic component of the ABG. If the HCO₃ is low and the pH is low the patient would have metabolic acidosis. They move in the *same* direction to match.

STEP 5 REFERS TO COMPENSATION. Compensation is the attempt by the body to maintain homeostasis by correcting the pH. The opposite system will do this.

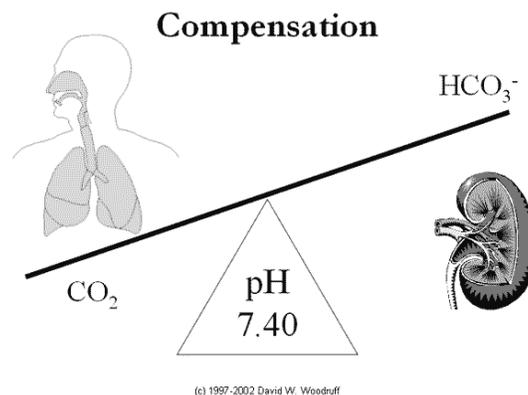
The component of the respiratory system that balances the pH is the dissolved carbon dioxide (CO₂) that is produced by cellular processes and removed by the lungs.

The component of the renal system that balances the pH is the dissolved bicarbonate (HCO₃) produced by the kidneys. The kidneys also help control pH by eliminating hydrogen (H⁺) ions. The way the two systems interact is through the formation of carbonic acid (H₂CO₃). Movement through the carbonic acid system is fluid and constant. What this means is that water (H₂O) can combine with CO₂ and form carbonic acid. If necessary, carbonic acid (H₂CO₃) can then break up to form hydrogen ions (H⁺) and bicarbonate (HCO₃). This system works in both directions. By balancing back and forth, a normal pH is achieved.

The respiratory system balances the pH by increasing or decreasing the respiratory rate, thereby manipulating the CO₂ level. Fast and deep breathing “blows off” CO₂. Conversely, slow and shallow breathing “retains” CO₂.

The renal system balances pH by producing HCO₃ or by eliminating hydrogen ions (H⁺).

The renal system will reflect changes in metabolic activity within the body. For example, a patient in shock will undergo anaerobic metabolism, which produces lactic acid. The production of lactic acid will bind or use up available HCO₃ and will be manifested by a decrease in the HCO₃ level. Therefore, the HCO₃ level is an indicator of metabolic acid-base balance.



Balance must always be achieved by the opposing system. If an adult were on one side of a seesaw and a small child on the other, we would expect the child's side of the seesaw to go up and the adult's side to go down. We cannot make the child go down by adding another adult to the adult's side. In the same way, our body regulates pH by using the opposing system to balance pH. So if the pH is out of balance because of a respiratory disorder, it will be the renal system that makes the corrections to balance the pH. Conversely, if the renal system is to blame for the pH disorder, the respiratory system will have to compensate. This process is called compensation.

Compensation may not always be complete. Complete compensation returns the pH balance to normal. There are times when the imbalance is too large for compensation to restore the pH to normal. This is called partial compensation.

Like the seesaw, compensation must come from the opposite system. Step 5 looks analyzes compensation by looking for the system that is going the opposite direction of the pH.

Examples with compensation will be presented later.

NOW LET'S PUT THE 6 STEPS INTO ACTION WITH AN EXAMPLE:

pH	7.27	acidotic
CO2	53	acidotic
pO2	50	low
O2 sat.	79%	low
HCO3	24	normal

Step 1: The pH is less than 7.35, therefore is acidotic.

Step 2: The CO2 is greater than 45, and is therefore acidotic.

Step 3: The HCO3 is normal.

Step 4: The CO2 matches the pH, because they are both acidotic. Therefore the imbalance is respiratory acidosis. It is acidotic because the pH is acidotic, it is respiratory because the CO2 matches the pH.

Step 5: The HCO3 is normal, therefore there is no compensation. If the HCO3 is alkalotic (opposite direction) then compensation would be present.

Step 6: Lastly, the PaO2 and O2 sat are low indicating hypoxemia.

The full diagnosis for this blood gas is:

Uncompensated respiratory acidosis with hypoxemia.

This patient has an acute respiratory disorder.

HERE'S ANOTHER EXAMPLE:

pH	7.52	alkalotic
CO2	29	alkalotic
pO2	100	normal
O2 sat.	98%	normal
HCO3	23	normal

Step 1: The pH is greater than 7.45, therefore is alkalotic.

Step 2: The CO2 is less than 35, and is therefore alkalotic.

Step 3: The HCO3 is normal.

Step 4: The CO2 matches the pH, because they are both alkalotic. Therefore the imbalance is respiratory alkalosis. It is alkalotic because the pH is alkalotic; it is respiratory because the CO2 matches the pH.

Step 5: The HCO3 is normal, therefore there is no compensation. If the HCO3 is acidotic (opposite direction) then compensation would be present.

Step 6: Lastly, the PaO2 and O2 sat are normal indicating normal oxygenation.

The full diagnosis for this blood gas is:
Uncompensated respiratory alkalosis.

This patient is probably hyperventilating.

HERE IS ANOTHER EXAMPLE:

pH	7.18	acidotic
CO2	44	normal
pO2	92	normal
O2 sat.	95%	normal
HCO3	16	acidotic

Step 1: The pH is less than 7.35, therefore is acidotic.

Step 2: The CO2 is normal.

Step 3: The HCO3 is less than 22, and is therefore acidotic.

Step 4: The HCO3 matches the pH, because they are both acidotic. Therefore the imbalance is metabolic acidosis. It is acidotic because the pH is acidotic, it is metabolic because the HCO3 matches the pH.

Step 5: The CO2 is normal, therefore there is no compensation. If the CO2 is alkalotic (opposite direction) then compensation would be present.

Step 6: Lastly, the PaO2 and O2 sat are normal indicating normal oxygenation.

The full diagnosis for this blood gas is:
Uncompensated metabolic acidosis.

This patient probably has an acute metabolic disorder such as DKA.

LET'S TRY ANOTHER:

pH	7.60	alkalotic
CO2	37	normal
pO2	92	normal
O2 sat.	98%	normal
HCO3	35	alkalotic

Step 1: The pH is greater than 7.45, therefore is alkalotic.

Step 2: The CO2 is normal.

Step 3: The HCO3 is greater than 26, and therefore is alkalotic.

Step 4: The HCO3 matches the pH, because they are both alkalotic. Therefore the imbalance is metabolic alkalosis. It is alkalotic because the pH is alkalotic, it is metabolic because the HCO3 matches the pH.

Step 5: The CO2 is normal, therefore there is no compensation. If the CO2 is acidotic (opposite direction) then compensation would be present.

Step 6: Lastly, the PaO2 and O2 sat are normal.

The full diagnosis for this blood gas is:
Uncompensated metabolic alkalosis.

This patient probably is losing stomach acid from vomiting or NG tube drainage.

ONE LAST EXAMPLE:

pH	7.30	acidotic
CO ₂	30	alkalotic
pO ₂	68	low
O ₂ sat.	92%	low
HCO ₃	14	acidotic

Step 1: The pH is less than 7.35, therefore is acidotic.

Step 2: The CO₂ is less than 35, and is therefore alkalotic.

Step 3: The HCO₃ is less than 22, and therefore is acidotic.

Step 4: The HCO₃ matches the pH, because they are both acidotic. Therefore the imbalance is a metabolic acidosis. It is acidotic because the pH is acidotic, it is metabolic because the HCO₃ matches the pH.

Step 5: The CO₂ is alkalotic and goes the opposite direction of the pH, so there is compensation. Because the pH is not in the normal range the compensation is called partial.

Step 6: Lastly, the PaO₂ and O₂ sat are low indicating hypoxemia.

The full diagnosis for this blood gas is:

Partially-compensated metabolic acidosis with hypoxemia.

There are a number of conditions that can cause metabolic acidosis: renal failure, diarrhea, poisonings, diabetic ketoacidosis, and shock, to name a few. This patient is probably in shock, because his metabolic acidosis associated with poor oxygenation.

THANK YOU FOR USING THE "6 EASY STEPS TO ABG ANALYSIS". KEEP THIS GUIDE HANDY, AS IT WILL BE VERY HELPFUL THE NEXT TIME YOU HAVE TO ANALYZE A BLOOD GAS.

The best way to become proficient at ABGs is to practice. Analyze all the blood gases you can get your hands on.

If you would like additional practice ABGs or ABG case studies visit our website at www.The-ABG-Site.com.

Get inspiration, motivation, and nursing news with the "Nurses' Morning Coach." Find out more at: www.Nurses-Morning-Coach.com.

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