Arterial Blood Gas (ABG) Analysis

The arterial blood gas (ABG) measures the acid-base balance (pH) and oxygenation of an arterial blood sample. An ABG is a tool used to assess respiratory compromise and medical conditions that cause metabolic abnormalities (such as sepsis, diabetic ketoacidosis [DKA], renal failure, toxic substance ingestion, drug overdose, trauma, or burns). ABG analysis can help determine the underlying cause of clinical deterioration or cardiac arrest as well as guide therapy during patient resuscitation. An ABG can also be used to evaluate the effectiveness of oxygen therapy, ventilatory support, fluid and electrolyte replacement, insulin therapy, and during perioperative care.

Normal Values

Normal Values and Clinical Significance		
Value	**Normal range**	**Clinical significance**
pH (Acidity)	7.35-7.45	The pH is a measurement of the acid content or hydrogen ions [H+] in the blood. Low pH (acidosis) indicates a higher concentration of hydrogen ions while a high pH (alkalosis) indicates a lower concentration of hydrogen ions.
$PaCO_2$ (Carbon dioxide tension)	35-45 mm Hg	The $PaCO_2$ level is the respiratory component of the ABG. The PaCO2 is affected by CO_2 removal in the lungs. A higher $PaCO_2$ level indicates acidosis while a lower $PaCO_2$ level indicates alkalosis.
HCO_3^- (Bicarbonate)	22-26 mEq/L	The HCO_3^- level is the metabolic component of the ABG and is affected by renal production of bicarbonate or by conditions causing bicarbonate loss. A lower HCO_3^- level indicates acidosis while a higher HCO_3^- level indicates alkalosis.
PaO_2 (Oxygen tension)	80-100 mm Hg	The PaO_2 level is a measurement of the amount of oxygen dissolved in the blood. A PaO_2 level less than 60 mm Hg results in tissue hypoxia.
SaO_2 (Oxyhemoglobin saturation)	95-100%	SaO_2 refers to the number of hemoglobin binding sites that have oxygen attached to them. How easily oxygen attaches to hemoglobin can be affected by body temperature, pH, 2,3-diphosphoglycerate levels, and CO_2 levels.

Six Steps for ABG Analysis

Normal Values and Clinical Significance	
Steps	**Clinical significance**
Step 1: Analyze the pH pH < 7.35 = acidosis pH > 7.45 = alkalosis	Determine if the pH is within the normal range or reflects acidosis or alkalosis.
Step 2: Analyze the $PaCO_2$ $PaCO_2$ > 45 = acidosis $PaCO_2$ < 35 = alkalosis	Carbon dioxide is produced in the tissues of the body and eliminated in the lungs. Changes in the $PaCO_2$ level reflect lung function.
Step 3: Analyze the HCO_3^- HCO_3^- < 22 = acidosis HCO_3^- > 26 = alkalosis	Bicarbonate is produced by the kidneys. Changes in the HCO_3^- level reflect metabolic function of the kidneys or bicarbonate loss (e.g., from diarrhea).
Step 4: Match the $PaCO_2$ or HCO_3^- with pH	
If pH < 7.35 and $PaCO_2$ > 45 and HCO_3^- level is normal, the patient has *respiratory acidosis.*	Causes of *respiratory acidosis* include hypoventilation, respiratory infection, severe airflow obstruction as in chronic obstructive pulmonary disease (COPD) or asthma, neuromuscular disorders, massive pulmonary edema, pneumothorax, central nervous depression, spinal cord injury, and chest wall injury.
If pH < 7.35 and HCO_3^- < 22 and $PaCO_2$ level is normal, the patient has *metabolic acidosis.*	Causes of *metabolic acidosis* include renal failure, DKA, lactic acidosis, sepsis, shock, diarrhea, drugs, and toxins such as ethylene glycol and methanol.
If pH > 7.45 and $PaCO_2$ < 35 and the HCO_3^- level is normal, the patient has *respiratory alkalosis.*	Causes of *respiratory alkalosis* include hyperventilation, pain, anxiety, early stages of pneumonia or pulmonary embolism, hypoxia, brainstem injury, severe anemia, and excessive mechanical ventilation.
If pH is > 7.45 and HCO_3^- > 26 and the $PaCO_2$ level is normal, the patient has *metabolic alkalosis.*	Causes of *metabolic alkalosis* include diuretics, corticosteroids, excessive vomiting, dehydration, Cushing syndrome, liver failure, and hypokalemia.
Step 5: Assess for compensation by determining whether the $PaCO_2$ or the HCO_3^- go in the opposite direction of the pH.	When a patient has an acid-base imbalance, the respiratory and metabolic systems try to correct the imbalances the other system has produced. There is full or partial compensation if the $PaCO_2$ or HCO_3^- go in the opposite direction of the pH.

If pH 7.35-7.40 (*compensated acidosis*), $PaCO_2$ > 45 (*acidosis*), and HCO_3^- > 26 (*alkalosis*), the patient has *compensated respiratory acidosis.*	To compensate for respiratory acidosis, the kidneys excrete more hydrogen ions and elevate serum HCO_3^-, in an effort to normalize the pH.
If pH 7.35-7.40 (*compensated acidosis*), $PaCO_2$ <35 (*alkalosis*), and HCO_3^- <22 (*acidosis*), the patient has *compensated metabolic acidosis.*	To compensate for metabolic acidosis, the patient's respiratory center is stimulated, and the patient hyperventilates to blow off more CO_2, raising the pH.
If pH 7.40-7.45 (*compensated alkalosis*), $PaCO_2$ <35 (*alkalosis*), and HCO_3^- < 22 (*acidosis*), the patient has *compensated respiratory alkalosis.*	To compensate for respiratory alkalosis, the metabolic system is activated to retain hydrogen ions and lower serum HCO_3^-, in an effort to raise the pH.
If pH 7.40-7.45 (*compensated alkalosis*), $PaCO_2$ > 45 (*acidosis*), and HCO_3^- > 26 (*alkalosis*), the patient has *compensated metabolic alkalosis.*	To compensate for metabolic alkalosis, the patient's respiratory center is suppressed; decreased rate and depth of respiration causes CO_2 to be retained, lowering the pH.
Step 6: Analyze the PaO_2 and SaO_2 If PaO_2 < 80 mm Hg or SaO_2 < 95%, the patient has *hypoxemia.*	Causes of hypoxemia include COPD, pneumonia, atelectasis, acute respiratory distress syndrome (ARDS), certain medications, high altitudes, interstitial lung disease, pneumothorax, pulmonary embolism, pulmonary edema, pulmonary fibrosis, anemia, heart disease, intracardiac shunt, and sleep apnea.

References:

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