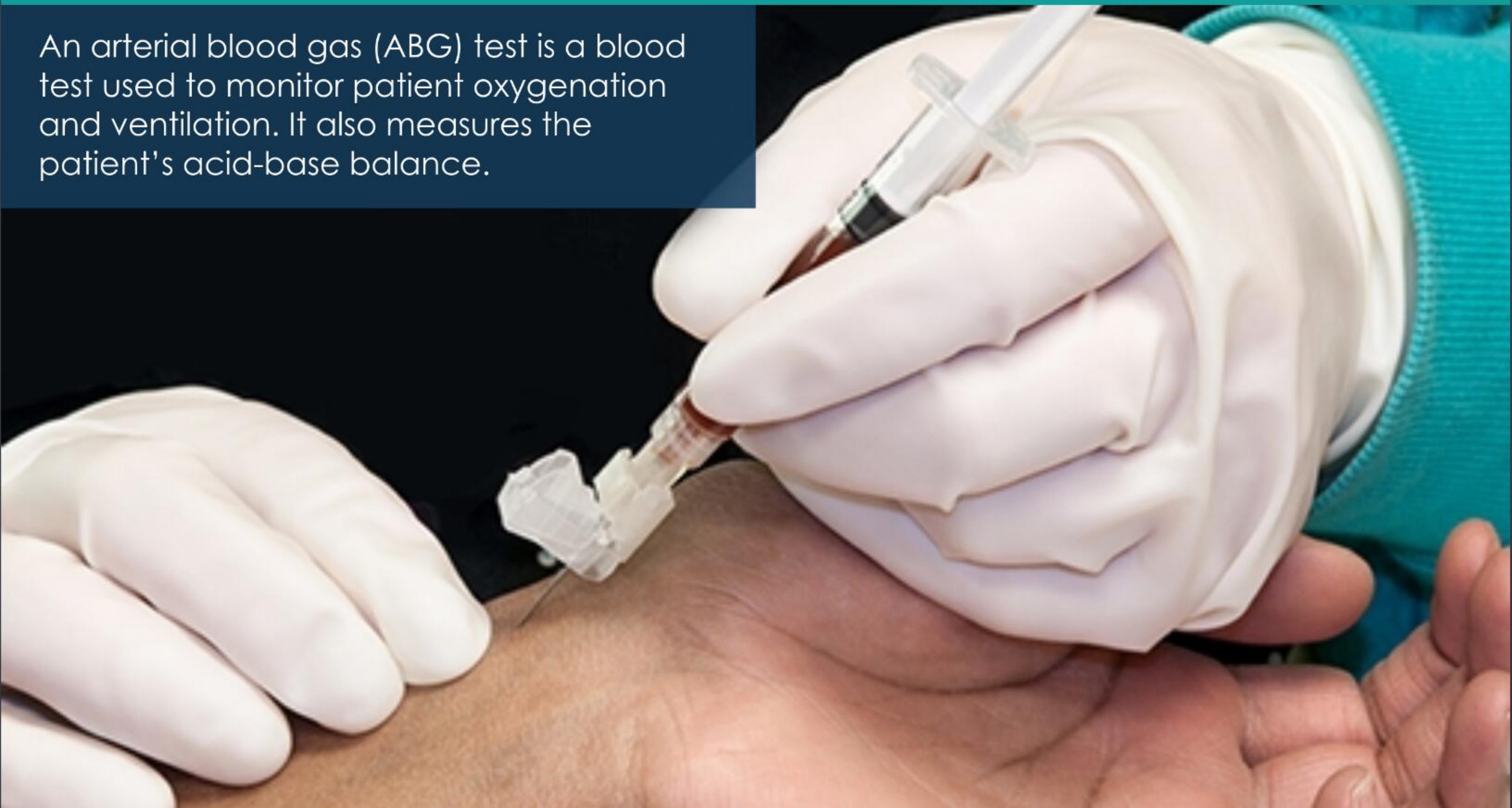
Topic Introduction

An arterial blood gas (ABG) test is a blood test used to monitor patient oxygenation and ventilation. It also measures the patient's acid-base balance.



Arterial Blood Gas (ABG) Sampling

ABGs are generally obtained to determine the adequacy of ventilation and oxygenation status.

Indications

Any patient who experiences clinical signs of hypoxia, hypercapnia, or changes in SpO_2 or partial pressure of end tidal CO_2 ($PetCO_2$) may benefit from an ABG test. Many medical interventions and medications can alter level of consciousness (LOC), which can ultimately impact ventilatory drive and oxygenation.

Technique

ABG blood samples are drawn from a peripheral artery. The most common site is the radial artery, because it is easily accessible and the hand has collateral flow through the ulnar artery. The brachial and femoral arterial sites are generally reserved for emergencies.

Allen's Test

Before puncture or placement of a radial arterial catheter, an Allen's test or Barbeau test is performed to evaluate blood flow through the ulnar artery. This ensures there is sufficient collateral circulation in the event of radial artery spasm or damage.

ABG Acid-Base Balance

When evaluating for possible acid-base imbalance, consider:

- Does the pH indicate acidosis or alkalosis?
- Is the cause respiratory or metabolic?
- Is there compensation for the imbalance?

Acid-Base Indicator	Lower Limit Normal	Upper Limit Normal
pH	7.35	7.45
$PaCO_2$	35	45
HCO_3^-	22	26

For more information on the ABG Decision Grid, go to the Tools menu and select Resources.

ABG Decision Grid

< each step in the procedure.

A systematic evaluation of ABG results can reveal an acid-base imbalance.

Sample ABG results:
pH: 7.22
$PaCO_2$: 38 mm Hg
HCO_3^-: 13 mEq/L

Step 1

Step 2

Step 3

Step 4

Step 5

Step 6

	Acidosis	Normal	Alkalosis
pH	<7.35	7.35-7.45	>7.45
$PaCO_2$	>45	35-45	<35
HCO_3^-	<22	22-26	>26

The ABG decision grid provides a framework for interpreting the three major components necessary to identify a specific acid-base abnormality.

ABG Decision Grid

Click each step in the procedure.

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	Acidosis	Normal	Alkalosis
pH	<7.35	7.35-7.45	>7.45
$PaCO_2$	>45	35-45	<35
HCO_3^-	<22	22-26	>26

Refer to the sample ABG results. Circle the values for pH, $PaCO_2$, and HCO_3^- that match the result.

Example: The pH is less than 7.35, indicating that the patient is acidotic.

ABG Decision Grid

Click each step in the procedure.

A systematic evaluation of ABG results can reveal an acid-base imbalance.

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	Acidosis	Normal	Alkalosis
pH	<7.35	7.35-7.45	>7.45
$PaCO_2$	>45	35-45	<35
HCO_3^-	<22	22-26	>26

The $PaCO_2$ (respiratory indicator) is between 35-45, so circle the center box.

ABG Decision Grid

Click each step in the procedure.

A systematic evaluation of ABG results can reveal an acid-base imbalance.

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	Acidosis	Normal	Alkalosis
pH	<7.35	7.35-7.45	>7.45
$PaCO_2$	>45	35-45	<35
HCO_3^-	<22	22-26	>26

Now, circle the value for HCO_3^- (metabolic indicator) that matches the sample ABG result.

ABG Decision Grid

Click each step in the procedure.

A systematic evaluation of ABG results can reveal an acid-base imbalance.

Sample ABG results:
pH: 7.22
$PaCO_2$: 38 mm Hg
HCO_3^-: 13 mEq/L

- Step 1
- Step 2
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	Acidosis	Normal	Alkalosis
pH	<7.35	7.35-7.45	>7.45
$PaCO_2$	>45	35-45	<35
HCO_3^-	<22	22-26	>26

When the pH is abnormal, examine the positions of the circled pH, $PaCO_2$, and HCO_3^- values. When pH and $PaCO_2$ are circled in the same column, the cause is respiratory. When pH and HCO_3^- are circled in the same column, the cause is metabolic.

ABG Decision Grid

Click each step in the procedure.

A systematic evaluation of ABG results can reveal an acid-base imbalance.

Sample ABG results:
pH: 7.22
$PaCO_2$: 38 mm Hg
HCO_3^-: 13 mEq/L

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	Acidosis	Normal	Alkalosis
pH	<7.35	7.35-7.45	>7.45
$PaCO_2$	>45	35-45	<35
HCO_3^-	<22	22-26	>26

Both acidotic pH and acidotic HCO_3^- are circled, indicating the patient has metabolic acidosis.

Q: What can ABG results be used to evaluate?

A: In addition to acid-base balance, the efficiency of oxygenation can be assessed by examining PaO_2 and SaO_2.

- PaO_2 is normally 80 to 100 mm Hg at sea level.
- SaO_2 is normally 95% to 100%.

Aerobic and Anaerobic Metabolism

If the body has insufficient oxygen supply, it compensates by increasing cardiac output, then switching to anaerobic metabolism. Compare and contrast aerobic and anaerobic metabolism.

Aerobic Metabolism (with Oxygen)

- Supplies the majority of energy needs
- Required for normal function of all metabolic processes

Anaerobic Metabolism (without Oxygen)

- Intended for short-term energy supply only
- Much less efficient; requires 20 times the fuel to produce the same amount of energy
- Produces large amounts of lactic acid in the tissues

Oxygenation Values

This table shows normal values for ABG parameters associated with oxygenation.

Oxygenation	Lower Limit Normal	Upper Limit Normal
PaO_2	80 mm Hg	100 mm Hg
SaO_2	95%	100%
The normal values for PaO_2 are at sea level.		

PaO_2 is the partial pressure of oxygen in arterial blood. PaO_2 creates the gradient for oxygen diffusion from the alveoli into the blood, and from blood into capillaries and tissues.

SaO_2 is the oxygen saturation level of arterial blood. Ninety-seven percent of the blood's oxygen is bound to hemoglobin.

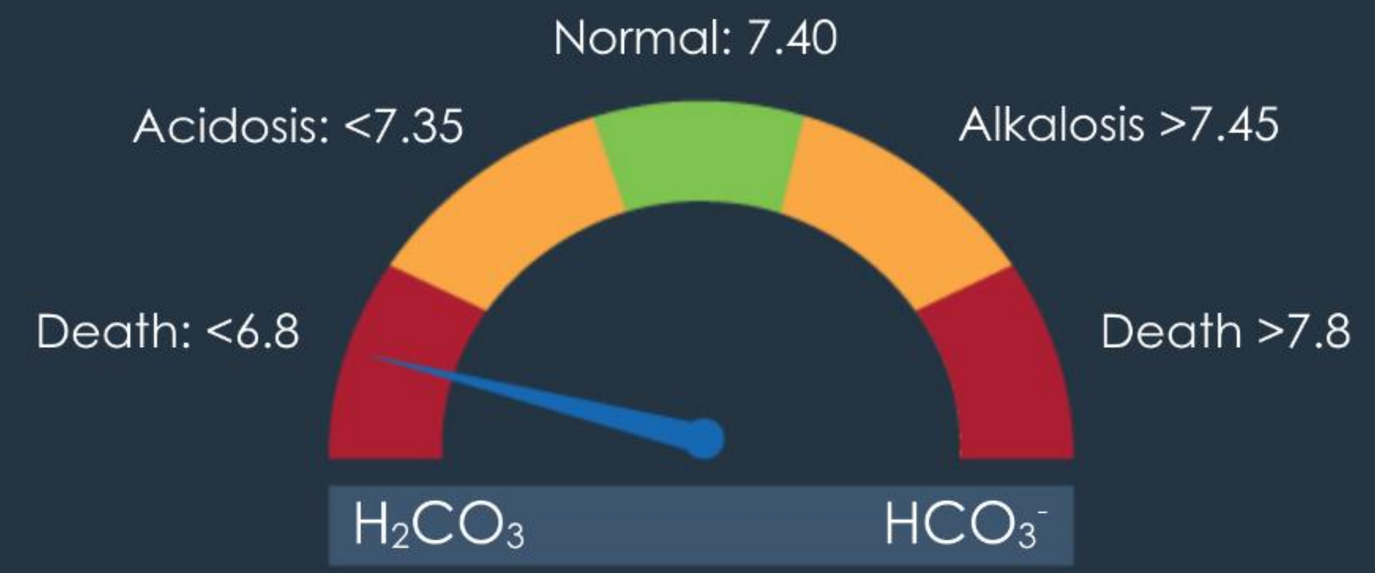
Acid-Base Balance

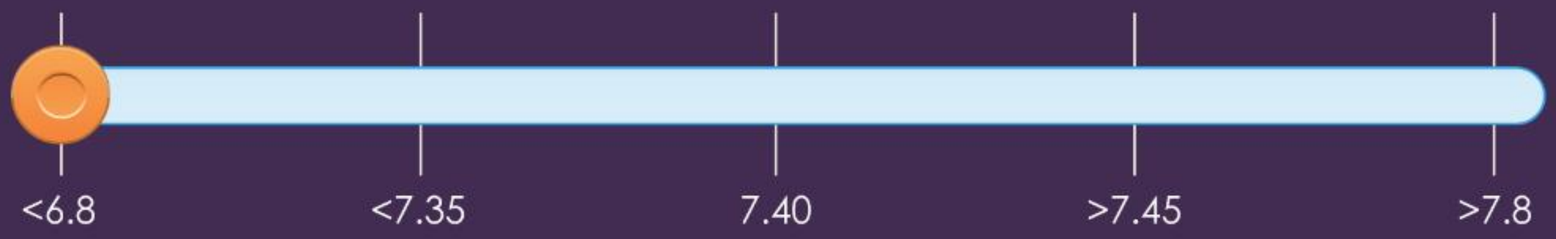
Use the slider to view the progression.

pH reflects the hydrogen ion (acid) concentration in the body. Examine the values along the pH range and what they signify.

Incompatible with Life

Any level below 6.8 indicates an acidosis that it is generally considered incompatible with life.





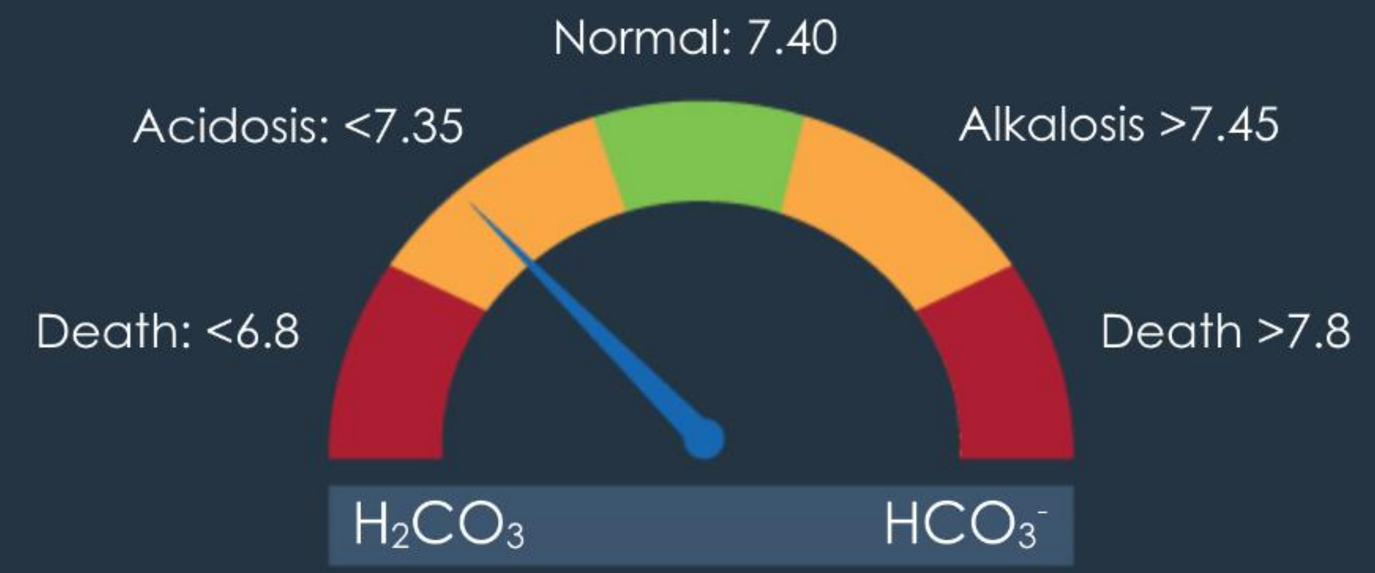
Acid-Base Balance

Use the slider to view the progression.

pH reflects the hydrogen ion (acid) concentration in the body. Examine the values along the pH range and what they signify.

Lower Limit Normal

- The lower limit normal is 7.35.
- In the presence of too many acids or too few bicarbonates, pH drops.
- Values under 7.35 are considered acidosis.



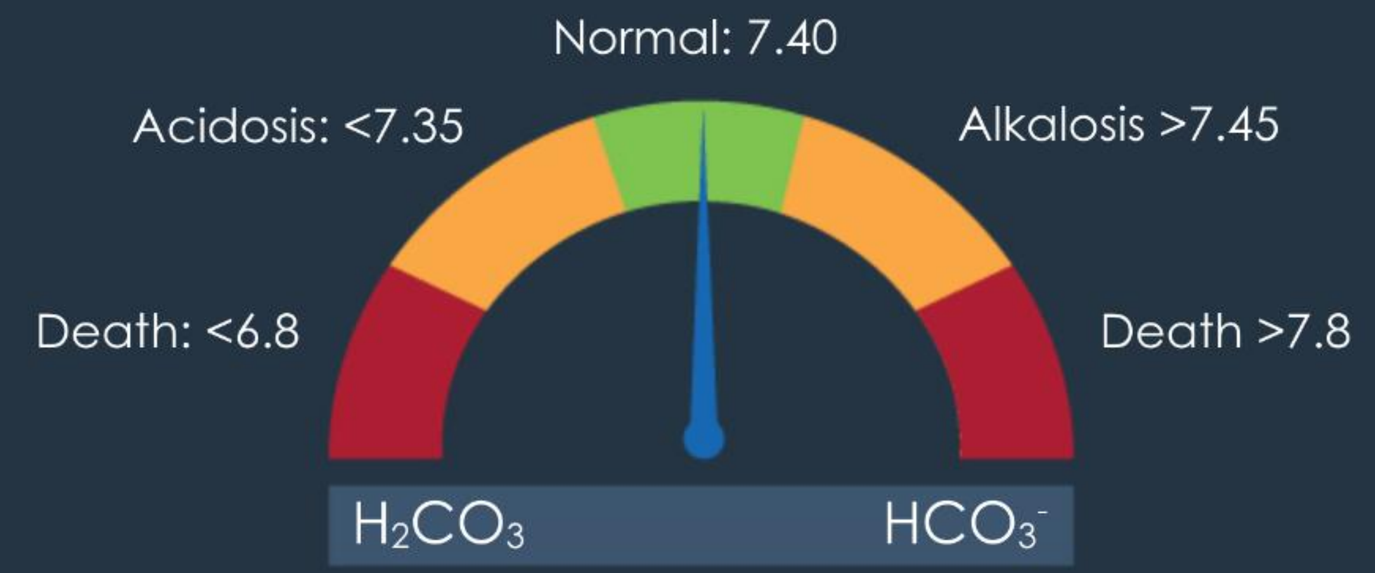
Acid-Base Balance

Use the slider to view the progression.

pH reflects the hydrogen ion (acid) concentration in the body. Examine the values along the pH range and what they signify.

Normal

- Normal pH is 7.40; normal range is 7.35-7.45.
- A slightly alkalotic state is required for proper function of most metabolic processes.



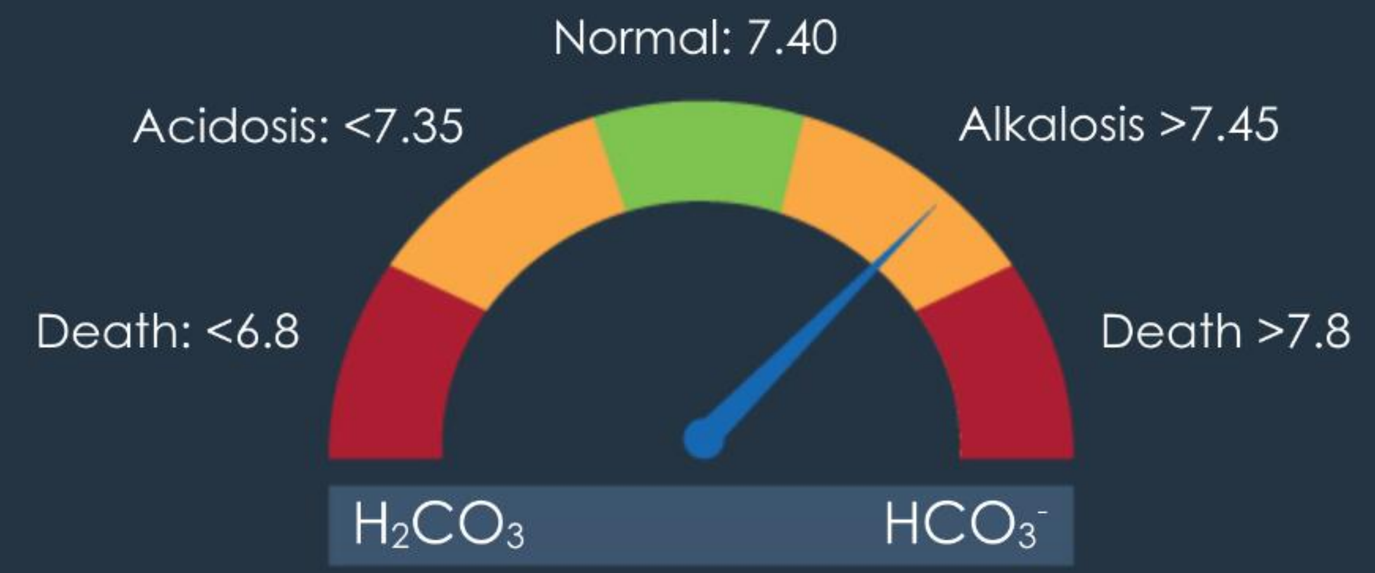
Acid-Base Balance

Use the slider to view the progression.

pH reflects the hydrogen ion (acid) concentration in the body. Examine the values along the pH range and what they signify.

Upper Limit Normal

- The upper limit normal is 7.45.
- In the presence of too few acids or too many bicarbonates, pH rises.
- Values over 7.45 are considered alkalosis.



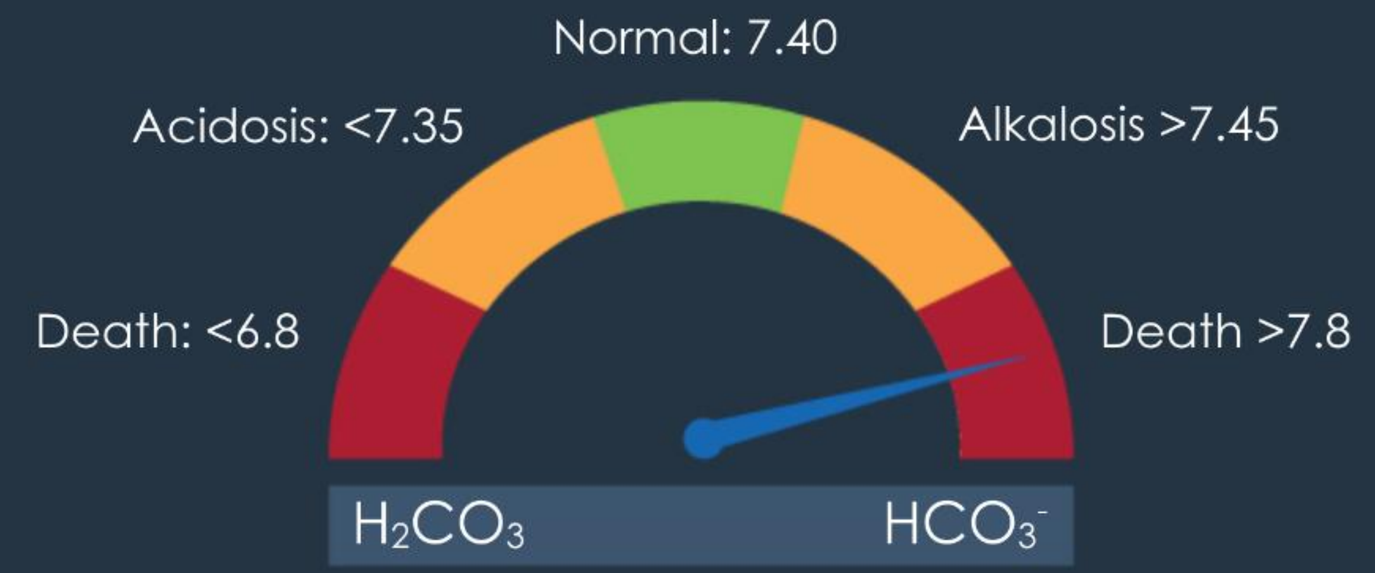
Acid-Base Balance

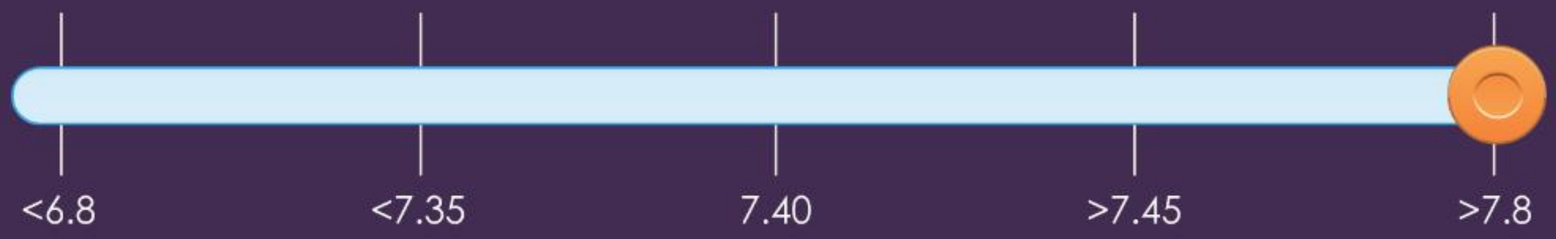
Use the slider to view the progression.

pH reflects the hydrogen ion (acid) concentration in the body. Examine the values along the pH range and what they signify.

Incompatible with Life

Any level above 7.8 indicates an alkalosis that it is generally considered incompatible with life.





Acid-Base Disorder

Click each tab to learn more.

- Overview
- Respiratory Acidosis
- Respiratory Alkalosis
- Metabolic Acidosis
- Metabolic Alkalosis

Overview

Acid-base disorders are either acidosis or alkalosis. They may be caused by a respiratory or metabolic problem.

Acid-Base Disorder

Click each tab to learn more.

Overview
Respiratory Acidosis
Respiratory Alkalosis
Metabolic Acidosis
Metabolic Alkalosis

Respiratory Acidosis

ABG Indicators
pH <7.35 and $PaCO_2$ >45 mm Hg

Etiology
Respiratory acidosis is the most common ABG abnormality. It results when the body produces carbon dioxide faster than the lungs can expel it. The most common cause is insufficient respiration and/or ventilation, also referred to as hypoventilation.

Causes
- Chronic obstructive pulmonary disease (COPD)
- Acute airway obstruction
- Analgesia and sedation
- Trauma
- Spinal cord injury
- Chest wall injury
- Neuromuscular disease
- Hypoventilation with mechanical ventilation

Acid-Base Disorder

Click each tab to learn more.

Overview
Respiratory Acidosis
Respiratory Alkalosis
Metabolic Acidosis
Metabolic Alkalosis

Respiratory Alkalosis

ABG Indicators
pH >7.45 and $PaCO_2$ <35 mm Hg

Etiology
Respiratory alkalosis is often caused by hyperventilation or over-breathing.

Causes
- Hypoxia
- Anxiety or fear
- Pain
- Stimulants
- Pulmonary embolus
- Hyperventilation with mechanical ventilation

Acid-Base Disorder

Click each tab to learn more.

Metabolic Acidosis

ABG Indicators
pH <7.35 and HCO_3^- <22

Etiology
Because systems other than the pulmonary system can be the source of a metabolic alteration, identifying the cause is a challenge. The entire clinical picture must be evaluated.

Causes
- Lactic acidosis
- Ketoacidosis
- Renal failure (acute or chronic)
- Rhabdomyolysis
- Ingestion of acids (methanol, salicylates, ethylene glycol)
- Diarrhea
- Ileostomy
- Pancreatic fistula

Acid-Base Disorder

Click each tab to learn more.

Metabolic Alkalosis

ABG Indicators
pH >7.45 and HCO_3^- >26

Etiology
The body is always producing acids, so metabolic alkalosis is a difficult physiologic state to achieve. The body in metabolic alkalosis attempts to compensate by retaining CO_2. This is demonstrated by reduced rate and depth of respiration. It is most often the result of interventions aimed to treat another underlying condition, such as:

- Sodium bicarbonate administration for cardiac arrest
- Over ingestion of common antacids
- Frequent blood transfusions
- Deprivation of normal body acids due to NG drainage, severe vomiting, or diuretics
- Steroid therapy

Respiratory Acidosis Patient Considerations

If CO_2 is building up in the blood, evaluate ventilation function.

Consider:

1. Is something causing decreased breathing rate or depth?
2. Is something impacting gas exchange at the alveoli, or is there excess fluid in the lungs?
3. Is the body creating CO_2 faster than it can be exhaled?

Compensatory Mechanisms

When arterial blood pH is outside the normal range, physiologic mechanisms will react to correct the acid-base balance.

Physiological Mechanisms

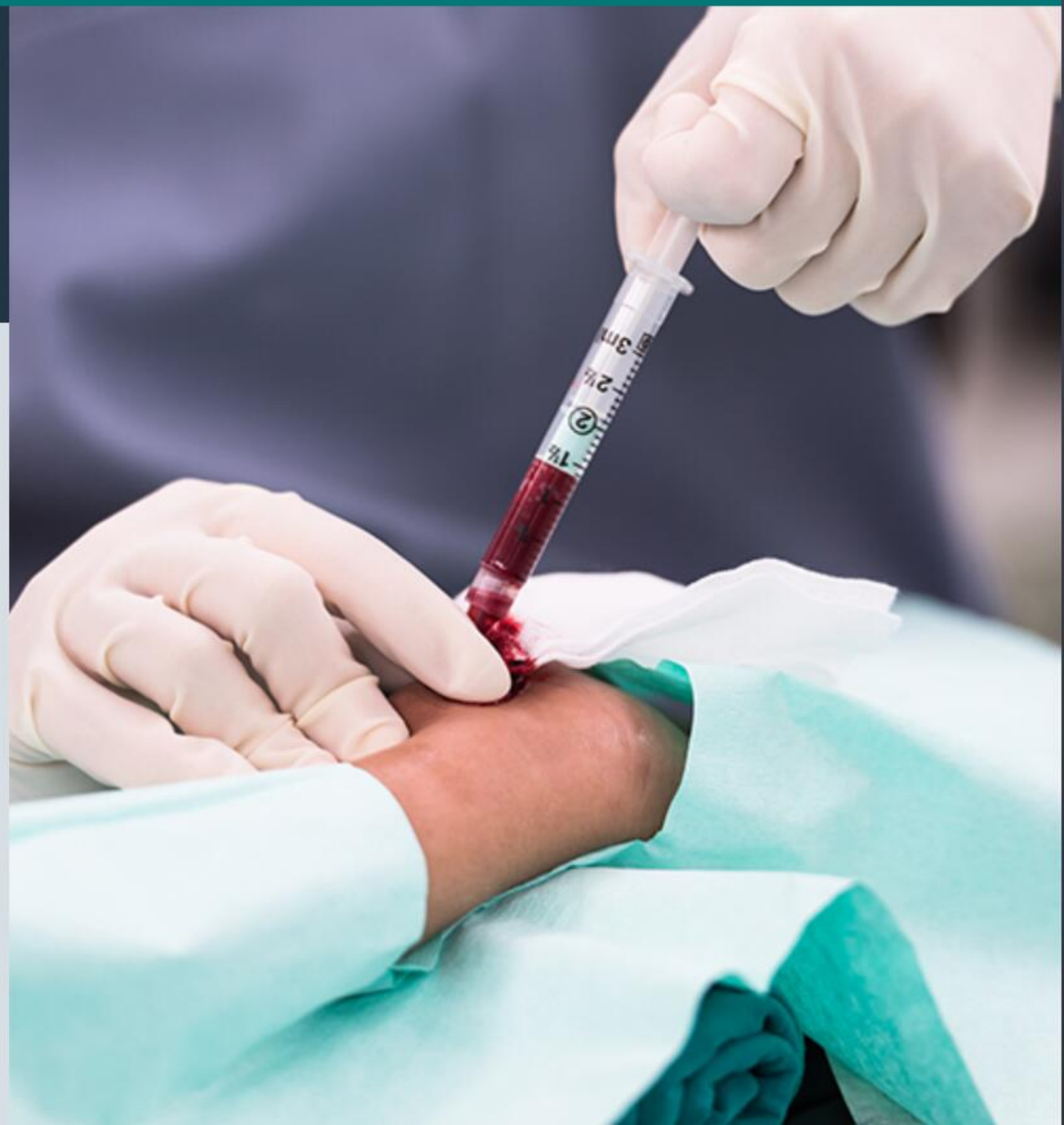
- Changes in ventilation occur immediately and affect the pH most quickly.
- The kidneys respond by altering the rate of HCO_3^- production or elimination. These effects take longer to change the pH.

ABG Results

- The correction of pH reflected in an ABG may be partial or complete. In partial compensation, the pH is still abnormal. In complete compensation, the pH is normal.
- When using the ABG decision grid, any circle on the opposite side of the pH is the compensatory mechanisms at work.
- When the pH is normal, use the ideal pH of 7.40 as the division between acidosis (<7.40) and alkalosis (>7.40).

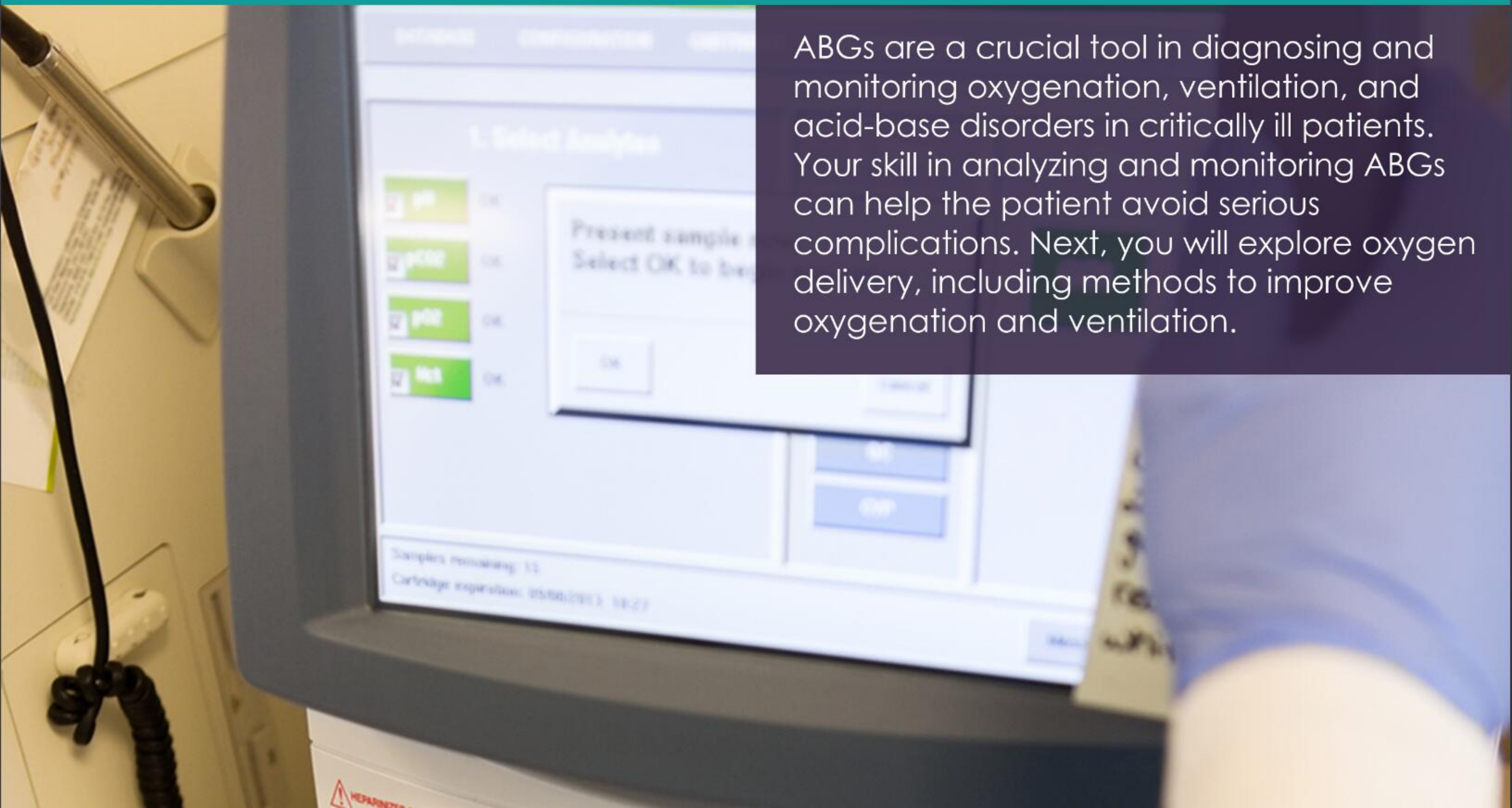
ABG Critical Values

Critical values on an ABG test generally depend on the patient's overall status, so knowing the patient's history, previous ABG results, and the amount of ventilatory support is important when trying to determine a critical change.



- Critical value: pH less than 7.2. Call provider for immediate evaluation.
- Metabolic and chemical processes cannot function; causes cardiac irritability and dysrhythmias.
- Vasoactive medications do not function properly.
- Patient may have abnormal ABG results on a chronic basis.
  - Patients with COPD have difficulty with exchange of CO_2 and high levels of $PaCO_2$.
  - Over time, the body chronically compensates with the kidneys, increasing the production of bicarbonate. This results in a compensated respiratory acidosis as a chronic state.

Topic Conclusion



ABGs are a crucial tool in diagnosing and monitoring oxygenation, ventilation, and acid-base disorders in critically ill patients. Your skill in analyzing and monitoring ABGs can help the patient avoid serious complications. Next, you will explore oxygen delivery, including methods to improve oxygenation and ventilation.