In The Name Of God

Disorders of Acid–Base Balance

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- *To maintain homeostasis, the human body employs many physiological adaptations. One of these is maintaining an acid-base balance.*
- *Control of acid-base balance depends on the kidneys, the lungs, and intracellular and extracellular buffers.*

$$CO_2 + H_2O \leftrightarrow H^+ + HCO_3^-$$

Buffers are substances that attenuate the change in pH that occurs when acids or bases are added to the body.

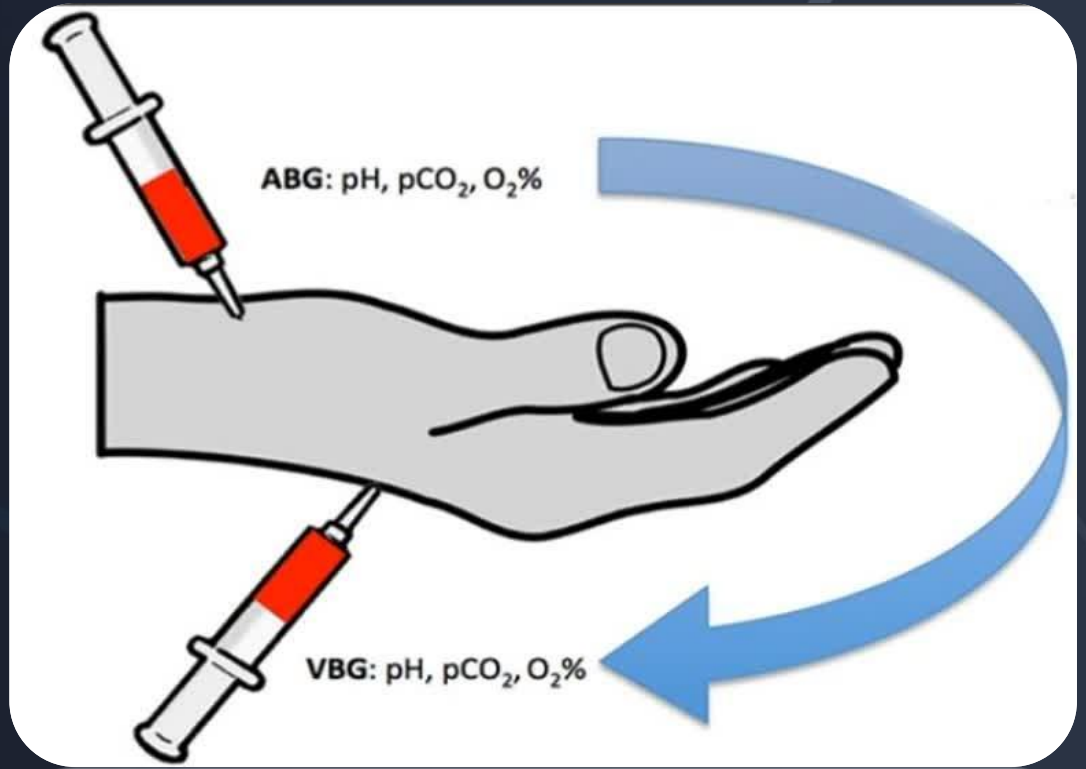
$$pH = 6.1 + \log[HCO_3^-]/[CO_2]$$

$$[H^+] = 24 \times PCO_2 / [HCO_3^-]$$

Henderson-Hasselbalch equation

ARTERIAL BLOOD GAS

- ***Advantages:***
- *gold standard test for determining : (pH, PaCO2, HCO3)*
- *can determine PaO2*
- ***Disadvantages:***
- *painful (should be performed with local anaesthetic in conscious patients)*
- *increased risk of bleeding and hematoma*
- *risk of pseudo aneurysm and AV fistula*
- *infection*
- *nerve injury*
- *digital ischemia*
- *clotted-blood embolism*
- *hematoma*
- *sympathetic dystrophy*



How to convert a VBG into an ABG?

Adjustment formula for ABG conversion from central VBG:

(1) arterial pH = venous pH + 0.03

(2) arterial Pco2 = venous Pco2 - 6 mm Hg.

pH	7.35-7.45
$[HCO_3^-]$	20-28 mEq/L
PCO_2	35-45 mm Hg

Normal Values of Arterial Blood Gases

Base Excess (BE) in an ABG

- The base excess is another surrogate marker of metabolic acidosis or alkalosis.
- A high base excess (> +5mmol/L) indicates that there is a higher than normal amount of HCO3- in the blood.
- A low base excess (< -5mmol/L) indicates that there is a lower than normal amount of HCO3- in the blood.

Terminology:

- Acidemia is a pH below normal (<7.35).
- Alkalemia is a pH above normal (>7.45).
- Acidosis is a pathologic process that causes an increase in [H+] .
- alkalosis is a pathologic process that causes a decrease in [H+]

A simple acid-base disorder is a single primary disturbance.

a metabolic acidosis, the decrease in the pH increases the ventilatory drive, causing a decrease in PCO2.

The decrease in the carbon dioxide concentration CO2 leads to an increase in the pH.

A mixed acid-base disorder is present when there is >1 primary acid-base disturbance.

Diagnosis

1. Acidemia or alkalemia is present?

2. Determine a cause of the acidemia or alkalemia.

METABOLIC ACIDOSIS

Etiology:

- *Diarrhea*
- *Renal tubular acidosis (RTA)*
- *Lactic Acidosis*
- *Tissue hypoxia*
- *Shock*
- *Hypoxemia*
- *errors of metabolism*
- *Diabetic ketoacidosis*
- *Starvation*
- *ketoacidosis Alcoholic ketoacidosis*
- *Kidney Failure*
- *Salicylate*

$$\text{Anion gap} = Na^{+} - [Cl^{-} + HCO_3^{-}]$$

Manifestations

- Related to the degree of acidemia:

  pH <7.2
- Impaired cardiac contractility increased risk of arrhythmias.
- Decrease in the cardiovascular response to catecholamines.
- Vasoconstriction of the pulmonary vasculature.
- Persistent pulmonary hypertension.

$$PCO_2 = 1.5 \times [HCO_3^-] + 8 \pm 2$$

5-years-old boy with a history of DKA:

- *PH:6.9*
- *Hco3:5*
- *Pco2:25*
- *BE:-20*
- *expected pCO2:13.5-17.5*

METABOLIC ALKALOSIS

Causes of Metabolic Alkalosis:

- CHLORIDE-RESPONSIVE (URINARY CHLORIDE <15 mEq/L)
- Gastric losses Emesis
- Nasogastric suction
- Diuretics (loop or thiazide)
- Chloride-losing diarrhea
- Cystic fibrosis
- Posthypercapnia
- CHLORIDE-RESISTANT (URINARY CHLORIDE >20 mEq/L)
- High Blood Pressure
- Adrenal adenoma or hyperplasia
- Renovascular disease
- Renin-secreting tumor 17α-Hydroxylase deficiency 11ß-Hydroxylase deficiency
- Liddle syndrome
- Normal Blood Pressure
- Gitelman
- Bartter syndrome

- *Loop Diuretic :volume depletion, which increases angiotensin II.*
- *Cystic fibrosis can cause metabolic alkalosis, hypokalemia, and hyponatremia because of excessive NaCl losses in sweat .*
- *Post hypercapnic metabolic alkalosis occurs after the correction of a chronic respiratory acidosis.*

Clinical Manifestations
METABOLIC ALKALOSIS

- Decrease in the ionized calcium concentration may cause symptoms of tetany (carpopedal spasm).
- Arrhythmias
- Hypoxia
- Decrease cardiac output

METABOLIC ALKALOSIS

- *PCO2 increases by 7 mm Hg for each 10 mEq/L increase in the serum [HCO3]*
- *[H]=PCO2/HCO3*

RESPIRATORY ACIDOSIS

Causes of Respiratory Acidosis:

- *RESPIRATORY MUSCLE WEAKNESS*
- *PULMONARY DISEASE*
- *CENTRAL NERVOUS SYSTEM DEPRESSION*

Hypercapnia causes :

- *Vasodilation in the cerebral vasculature.*
- *Vasoconstriction of the pulmonary circulation*
- *Increases the risk of cardiac arrhythmias*

- ***Acute respiratory acidosis:***
- ***Plasma bicarbonate increases by 1 for each 10 mm Hg***
- ***Increase in the PCO2 (acute compensation).***
- ***Chronic respiratory acidosis:***
- ***Plasma bicarbonate increases by 3.5 for each 10 mm Hg increase in the PCO2 (chronic compensation).***

RESPIRATORY ALKALOSIS

- *paresthesias*
- *tetany*
- *seizures*
- *muscle cramps*
- *syncope*
- *reduction in cerebral blood flow*
- *reduction in ionized calcium (occurs because alkalemia causes more calcium to bind to albumin).*
- *mild reduction in the serum potassium level.*

- *The metabolic response to an acute respiratory alkalosis is predictable: Plasma bicarbonate falls by 2 for each 10 mm Hg decrease in the PCO2*
- *(acute compensation).*
- *Plasma bicarbonate falls by 4 for each 10 mm Hg decrease in the PCO2*
- *(chronic compensation).*
- *[H]=PCO2/HCO3*

THE END.