Acid-base balance

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Acid-base balance

* Acids are electrolytes that release hydrogen ions (H+) when they are dissolved in water.
* Bases are electrolytes are release hydroxide ions (OH-) when they are dissolved in water
* Acid-base balance is primarily regulated by the concentration of H+ (or the pH level) in body fluids, especially ECF
* Normal pH range of ECF is from ٧.٣٥ to ٧.٤٥.
* Most H+ comes from metabolism -- glycolysis, oxidation of fatty acids and amino acids, and hydrolysis of proteins.
* Homeostasis of pH in body fluids is regulated by acid-base buffer systems (primary control), respiratory centers in brain stem, and by kidney tubule secretion of H+

Acid-base buffer systems are chemical reactions that consist of a weak acid and a weak base, to prevent rapid, drastic changes in body fluid pH . one of the most carefully regulated conc. in the body is that of H+ ion.

* one of the most carefully regulated conc. in the body is that of H+ ion. When acid (H+) is added to the blood, the pH decreases. Then increased acidity decreased pH) is minimized by buffers which bind some of the added H+

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* The pair bicarbonate / carbonic acid forms an important buffer system. H٢CO٣ carbonic acid) is the acid member of the pair because it can release H+. HCO٣)

- is the base member of the pair because H . it can accept H+. This system is important because two of its components are rigorously controlled by the body: the lungs control CO٢ and the kidney control HCO٣

Chemical Acid-Base buffer systems

١. Bicarbonate buffer system:

* Bicarbonate ion (HCO٣-) – converts a strong acid into a weak acid.
* Carbonic acid (H٢CO٣) – converts a strong base into a weak base.
* Bicarbonate buffer system produces carbonic acid (H٢CO٣) and sodium bicarbonate (NaHCO٣) to minimize H+ increase, mainly in the blood

٢. Phosphate buffer system: produces sodium hydrogen phosphates (NaH٢PO٤) to regulate H+ levels, mainly in kidney
tubules and erythrocytes:

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٣. Protein buffer system: relies on the carboxylic acid group of amino acids to release H+, and the amino group to accept H+, mainly inside body cells and in blood plasma

Respiratory centers in medulla oblongata regulate the rate and depth of breathing, which controls the amount of carbon dioxide gas ($CO^{٢}$) remained in the blood and body fluid -- e.g. slower berating rate an increase in blood $CO^{٢}$ level an increase in carbonic acid ($H^{٢}CO^{٣}$) in blood، more H+ is released into body fluids pH of blood and body fluids drops.

Nephrons react to the pH of body fluids and regulate the secretion of H+ into urine -- e.g. a diet high in proteins causes more H+ to be produced in body fluids (which lowers body fluid pH), as a result the nephrons will secrete more H+ into the urine

Compensation

Compensation is a series of physiological responses that react to acid-base imbalances, by returning blood pH to the normal range (٧.٣٥ – ٧.٤٥).

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Respiratory acidosis: (due to deficiency of $CO^{٢}$ expiration) and respiratory alkalosis (due to abnormally high $CO^{٢}$ expiration) are primary disorders of $CO^{٢}$ pressure in the lungs. These may be compensated by renal mechanisms where nephrons will secrete more H+ to correct acidosis and secrete less H+ to correct alkalosis.

- It is due to increased $CO^{٢}$ retention (due to hypoventilation), which can result in the accumulation of carbonic acid and thus a fall in blood pH to below normal.

Metabolic Acidosis: increased production of acids such as lactic acid, fatty acids, and ketone bodies, or loss of blood bicarbonate (such as by diarrhea), resulting in a fall in blood pH to below normal.

Respiratory Alkalosis:

A rise in blood pH due loss of $CO^{٢}$ and carbonic acid (through hyperventilation).

Metabolic Alkalosis:

A rise in blood pH produced by loss of acids (such as excessive vomiting) or by excessive accumulation of bicarbonate base.

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Respiratory Excretion of CO_2

* The respiratory center is located in the brain stem.
* It helps control pH by regulating the rate and depth of breathing.
* Increasing CO_2 and H+ ions conc. stimulate chemo receptors associated with the respiratory center; breathing rate and depth increase, and CO_2 conc. decreases.
* If the CO_2 and H+ ion concentrations are low, the respiratory center inhibits breathing

Renal excretion of H+

- Nephrons secrete hydrogen ions to regulate pH .
- phosphate buffer hydrogen ions in urine.
- Ammonia produced by renal cells help transport H+ to the outside of the body:
- chemical buffer system (Bicarbonate buffer system, phosphate buffer, and protein buffer system) act rapidly and are the first line of defense against pH shift.

Factors Associated with Edema

١. Low plasma protein concentration: cause is liver disease, kidney disease, loss of protein in urine, lack of protein in diet due to starvation.

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Effect: plasma osmotic pressure decreases, less fluid enters venular end of capillaries by osmosis.

٢. Obstruction of lymph vessels: causes are surgical removal of portions of lymphatic pathways and parasitic infections.

Effect: back pressure in lymph vessels, interferes with movement of fluid from interstitial spaces into lymph capillaries.

٣. Increased venous pressure: venous obstruction or faulty valves.

Effect: back pressure in veins increases capillary filtration and interferes with return of fluid from interstitial spaces into venular end of capillaries.

٤. Inflammation: cause is tissue damage.

Effect: capillaries become abnormally permeable and fluid leaks from plasma into the interstitial spaces