Acid-base balance

Introduction

Our body continuously produces acid in the form of hydrogen ions (H+) as a result of metabolism. diets rich in meat lead to more acid production than those rich in fruits and vegetables. The concept of Acid-base balance is concerned with maintaining a normal hydrogen ion concentration in the body fluids.

pH of Body Fluids

The normal plasma concentration of H+ is 40 nmol/litre or 0.00004 mmol/litre. (H^+) concentration is routinely expressed as pH, which mean negative logarithm of H^+ concentration:

$$pH = - \log_{10}[H^+]$$

The normal arterial pH is about 7.4. The H+ concentration (pH) of the blood must be maintained within a narrow range, between 7.35 and 7.45, for the cells of the body to function properly.

BUFFER SYSTEMS

Any substance that can reversibly bind H+ is considered as a buffer

$$\text{Buffer} + H^+ \rightleftharpoons H\ \text{Buffer}$$

Defenses against changes in hydrogen ion concentration:

There are three primary systems that regulate the H+ concentration:
(1) the chemical acid-base buffer systems of the body fluids.
(2) the respiratory system.
(3) the kidneys.

The chemical acid-base buffer systems

I.Bicarbonate Buffer System

This system consist of **H2CO3** (weak acid)and **NaHCO3**(weak base)

II. Phosphate Buffer System

This system consist of NaH2PO4 (weak acid) and **Na2HPO4**(weak base)

III.Protein Buffer System

Protein is important intracellular buffer system. In the red blood cell, hemoglobin (Hb) is an important buffer.

Respiratory Regulation of Acid-Base Balance

The second line of defense against acid-base disturbances is control of ECF CO2 concentration by the lungs. whenever the H+ concentration increases above normal, the respiratory system is stimulated, and alveolar ventilation increases. This decreases the PCO2 in extracellular fluid and reduces H+ concentration back toward normal. Conversely, if H+ concentration falls below normal, the respiratory center becomes depressed, alveolar ventilation decreases, and H+ concentration increases back toward normal.

Renal Regulation of Acid-Base Balance

The kidney is important in acid-base balance. It can regulate the body pH by conserving or eliminating the bases (e.g., bicarbonate) or acids (e.g., hydrogen ions). The kidney has the capacity to secrete hydrogen ions into the tubular fluid. Large quantities of hydrogen ions can be eliminated because of the presence of buffers in the urine that combine with the hydrogen ions. (Buffers are substances that combine with hydrogen ions to form weaker acids).

The three major urinary buffers are

* bicarbonate(HCO3-).
* phosphate (HPO4-)
* ammonia (NH3).

Bicarbonate present in the filtrate combines with hydrogen ions to form carbonic acid (a weak acid). This acid dissociates into water and carbon dioxide. The carbon dioxide diffuses into the cells and is used to form more bicarbonate ions.

$$H^+ + HCO_3^- \rightarrow H_2CO_3 \rightarrow H_2O + CO_2$$

Hydrogen ion + Bicarbonate ion →
Carbonic Acid → Water + Carbon dioxide

Similarly, filtered phosphate combines with the secreted hydrogen ions and is excreted. The tubular cells manufacture ammonia from the amino acid glutamine. The ammonia combines with hydrogen ions and is also excreted. When the blood pH is alkaline, fewer hydrogen ions are secreted and more bases excreted.-

Large Changes in pH May Result in Acidosis or Alkalosis

Acid–base imbalances lead to changes in blood pH, leading to:

- Acidosis, a condition in which blood pH is below 7.35.
- Alkalosis, a condition in which blood pH is higher than 7.45.

Acidosis depresses the central nervous system , the individual becomes disoriented, then becomes comatose, and may die.

Alkalosis causes overexcitability in both the central nervous system and peripheral ; the results are nervousness, muscle spasms, and even convulsions and death.

There are two forms of acidosis and alkalosis:

1.Metablic

Acidosis caused by a primary decrease in bicarbonate concentration is termed metabolic acidosis, whereas alkalosis caused by a primary increase in bicarbonate concentration is called metabolic alkalosis.

2.respiratory

Acidosis caused by an increase in PCO2 is called respiratory acidosis, whereas alkalosis caused by a decrease in PCO2 is termed respiratory alkalosis.

Table Changes in arterial blood composition in acid–base disturbances

Disturbance	pH	$[HCO_3^-]$	CO_2
Respiratory alkalosis	↑	↓	↓
Metabolic alkalosis	↑	↑	—
Respiratory acidosis	↓	↑	↑
Metabolic acidosis	↓	↓	—

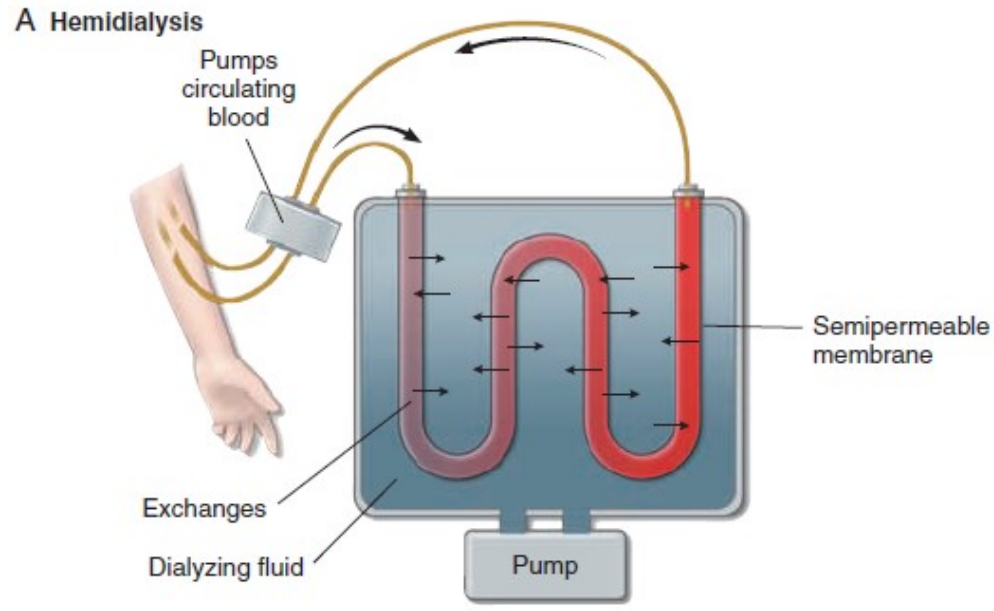
Key: ↑ = above normal; ↓ = below normal; — = normal

DIALYSIS OR ARTIFICIAL KIDNEY

When the kidneys cannot function adequately(renal failure), an artificial kidney may need to be used to remove waste products from the extracellular fluid. Dialysis involves use of a machine that contains a semipermeable membrane that separates the dialysis fluid and the blood of the individual. Toxic substances that are of a higher concentration in the blood diffuse across the membrane into the dialysis fluid and nutrients and other required ions, which are of a higher concentration in the fluid, diffuse into the blood. Dialysis can be done in two ways:

(1.) shunting blood from an artery through the machine and back into a vein (hemodialysis),

(2.) using the peritoneal membrane as a dialysis membrane (peritoneal dialysis).



B Peritoneal dialysis