**Water Homeostasis**

The average water content of the human body 40% to 75% of total body weight, values declining with age and especially with obesity. Women have lower average water content than men as a result of a higher fat content

**FUNCTIONS**

1-Water is the solvent for all processes in the human body.

2-It transports nutrients to cells

3-determines cell volume by its transport into and out of cells

4-removes waste products by way of urine

5-acts as the body’s coolant by way of sweating.

**WATER COMPARTMENTS**

-Intracellular fluid (ICF) it accounts for about two thirds of total body water.

-Extracellular fluid (ECF) accounts for the other one third of total body water and can be subdivided into :-

*\*intravascular extracellular fluid (plasma)*

*\*interstitial cell fluid that surrounds the* cells in the tissue.

**Osmolality**

is a physical property of a solution that is based on the concentration of solutes (expressed as millimoles)per kilogram of solvent (w/w). Osmolality is related to colligative properties of a solution relative to pure water, such as freezing point depression and vapor pressure decrease.

The osmolarity is reported in milliosmoles per liter (w/v), but it is inaccurate in hyperlipidemia and hyperproteinemia

**Control of Osmolality**

1-hypothalamus:

-Thirst center

-Arginine- vasopressin, AVP( ADH)

2-Renal water regulation by ADH and thirst play important roles in regulating plasma osmolality.

**Clinical Significance of Osmolality**

-The Na and its associated anions account for approximately 90% of the osmotic activity in plasma.

-Another important process affecting the Na concentration in blood is the regulation of blood volume.

-To maintain a normal plasma osmolality (275–295 mOsm/kg of plasma H2O), osmoreceptors in the hypothalamus respond quickly to small changes in osmolality.

-A 1%–2% increase in osmolality causes a fourfold increase in the circulating concentration of ADH, and a 1%–2% decrease in osmolality shuts off ADH production..

**Water Load**

1-As excess intake of water (e.g., in polydipsia)

2- lower plasma osmolality

3- both AVP and thirst are suppressed.

4- In the absence of AVP, water is not reabsorbed

5- large volume of dilute urine to be excreted, as much as 10 to 20 L daily, well above any normal intake of water.

**Water Deficit**

1- increase plasma osmolality

2- both AVP secretion and thirst are activated .

Although AVP contributes by minimizing renal water loss, thirst is the major defense against hyperosmolality and hypernatremia.

3-Osmotic stimulation of thirst progressively diminishes in people who are older than age 60

4- Patient with diabetes insipidus (no AVP) may excrete 10 L of urine per day however, because thirst persists, water intake matches output and plasma Na remains normal

**Regulation of Blood Volume**

1-The renin-angiotensin /aldosterone system

2-Atrial natriuretic peptide (ANP

3- Volume receptors

4-Glomerular filtration rate (GFR)

5- Plasma Na

**Electrolytes**

Electrolytes are ions capable of carrying an electric charge.

Anions have a negative charge and move toward the anode Cations migrate in the direction of the cathode because of their positive charge.

**Electrolytes are an essential component in numerous processes**

-volume and osmotic regulation (sodium [Na], chloride [Cl], potassium [K])

-myocardial rhythm and contractility (K, magnesium [Mg2],calcium [Ca2])

-cofactors in enzyme activation (e.g.,Mg2, Ca2, zinc [Zn2])

-regulation of adenosine triphosphatase (ATPase) ion pumps (Mg2)

-acid-base balance (bicarbonate [HCO3 ], K, Cl)

-blood coagulation (Ca2, Mg2)

-neuromuscular excitability (K, Ca2,Mg2)

-the production and use of ATP from glucose (e.g., Mg2, phosphate [PO4]).

**Sodium (Na )**

is the most abundant cation in the ECF, representing 90% of all extracellular cations .largely determines the osmolality of the plasma. A normal plasma osmolality is being the result of Na and associated anions. The Na,K- ATPase ion pump moves three Na ions out of the cell in exchange for two K ions moving into the cell as ATP is converted to ADP. Because water follows electrolytes across cell membranes, the continual removal of Na from the cell prevents osmotic rupture of the cell by also drawing water from the cell.

**Clinical Applications**

Hyponatremia is defined as a serum/plasma level less than 135 mmol/L. Hyponatremia can be assessed by the cause for the decrease or with the osmolality level.

CAUSES:-

\*INCREASED SODIUM LOSS such as Hypoadrenalism and Potassium deficiency( K deficiency also causes Na loss because of the inverse relationship of the two ions in the renal tubules).

\*INCREASED WATER RETENTION such as Renal failure: Increased water retention causes serum dilution

\* WATER IMBALANCE such as excess water intake and SIADH

Hypernatremia

Causes:-

\* Excess loss of water relative to Na loss such as Diabetes insipidus and Renal tubular disorder

\*decreased water intake such as Older persons and Infants

\*Increased Na intake or retention Hyperaldosteronism and Sodium bicarbonate excess

**POTASSIUM (K)**

Is the major intracellular cation, with a concentration 20 times greater inside the cells than outside. . only 2% of the body’s total K circulates in the plasma.

**Functions**

Regulation of :

neuromuscular excitability

contraction of the heart

ICF volume

H⁺ concentration

The K concentration has a major effect on the contraction

of skeletal and cardiac muscles. Severe hyperkalemia can ultimately cause a lack of muscle contraction which may lead to paralysis or a fatal cardiac arrhythmia.

**Clinical Applications**

Hypokalemia

CAUSES :-

\*Increased losses such as GI LOSS (Vomiting and Diarrhea) and RENAL LOSS (Nephritis and Hyperaldosteronism)

\* DECREASED INTAKE

\* CELLULAR SHIFT

HYPERKALEMIA

CAUSES :-

\*DECREASED RENAL EXCRETION such as

\*CELLULAR SHIFT such as Acidosis and Chemotherapy

\*INCREASED INTAKE Oral or IV potassium replacement therapy

\* ARTIFACTUAL

**CAUSES OF ARTIFACTUAL HYPERKALEMIA.**

the coagulation process releases K from platelets, so that serum K may be higher than plasma K . In thrombocytosis, serum K may be further elevated.

if a tourniquet is left on the arm too long or if patients excessively clench their fists may release K into the plasma.

3.storing blood on ice promotes the release of K from cells, so, whole blood samples for K determinations should be stored at room temperature and analyzed promptly or centrifuged to remove the cells

**Chloride**

is the major extracellular anion. is involved in maintaining osmolality, blood volume, and electric neutrality. Cl ingested in the diet is almost completely absorbed by the intestinal tract. Cl is then filtered out by the glomerulus and passively reabsorbed, with Na, by the proximal tubules. Excess Cl is excreted in the urine and sweat. Excessive sweating stimulates aldosterone secretion, which acts on the sweat glands to conserve Na and Cl.

Chloride maintains electrical neutrality in two ways:-

1. Na is reabsorbed along with Cl in the proximal tubules. Cl acts as the rate-limiting component. Na reabsorption is limited by the amount of Cl available.

*2. chloride shift.* In this process*, carbon dioxide (CO2)* generated by cellular metabolism within the tissue diffuses out into both the plasma and the red cell.

**Clinical Applications**

HYPERCHLOREMIA excess loss of HCO3 as a result of GI losses and Renal tubular acidosis

HYPOCHLOREMIA

occur with excessive loss of Cl from prolonged vomiting and diabetic ketoacidosis

**Bicarbonate**

- Is the second most abundant anion in the ECF.

-Total CO2 comprises:

bicarbonate ion (HCO3). 90% of the total CO2 at physiologic pH

carbonic acid (H2CO3)

dissolved CO2.

- HCO3 is the major component of the buffering system in the blood. Carbonic anhydrase in RBCs converts CO2 and H2O to carbonic acid, which dissociates into H and HCO3