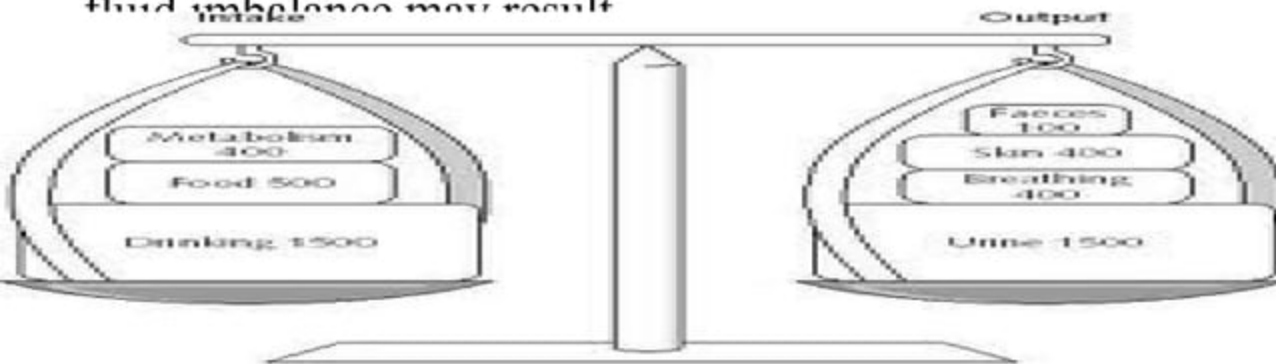


Fluid and Electrolyte Balance

By

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Water Balance

- When Water intake equals water loss, the body is in fluid balance. Fluid balance is the concept of human homeostasis
- When water loss is greater than intake, or vice versa, a fluid imbalance may result



FLUID & ELECTROLYTE

LOSS



REPLACEMENT



FIG. 28

Introduction

- The body maintains its internal environment by balancing the amounts, volume and composition of water, electrolytes, proteins, acids and bases. The most abundant constituent of the body is water, which accounts for 60% of body mass.
- Within this, water is dissolved or suspended the elements and formed substances which needed to generate energy, maintain and manufacture the body components, metabolize the nutrients and drugs and eliminate wastes.
- Salt and water balance in the body is maintained by the equilibrium between the intake of fluid and electrolytes, evaporation of solute free water across the skin and lungs and controlled renal excretion of water and electrolytes. The amount of water that evaporates is function of body surface area and respiratory rate.

Maintenance needs per hour

| WATER | |
|---|--|
| 0-10kg/body wt | 100ml/kg |
| 10-20 kg/body wt | 50ml/kg |
| >20kg/body wt | 20ml/kg |
| <u>ELECTROLYTES</u> | |
| Na | 3mmol/kg |
| K | 2mmol/kg |
| Cl | 2mmol/kg |
| Ca | 0.05-0.1mmol/kg |
| Mg | 0.05mmol/kg |
| Po4 | 0.1mmol/kg |
| <u>NORMAL SERUM LEVELS OF ELECTROLYTES</u> | |
| Na | 135-145mmol/L |
| K | 3.5-5.0mmol/L |
| Cl | 96-106mmol/L |
| Ca | Total: 2.15mmol/L Ionized: 1.19-1.37mmol/L |
| P | 0.80-1.44mmol/L |
| Urea | 3.0-8.0mmol/L |
| Glucose | Fasting: 3.3-6.0mmol/L Non-fasting: <11.0mmol/L |

Hypovolemia

- It is a state of decreased blood volume; loss of blood volume due hemorrhaging or dehydration decreased in volume of blood plasma. It is characterized by sodium depletion but, it differs from dehydration

Causes: Dehydration, bleeding, vomiting, severe burns, alcohol consumption, ruptured PCOS, drugs like vasodilators.

Symptoms: Nauseated, thirsty, dizzy, fatigue, weakness, muscle cramps, oligurea, bleeding, confusion, cyanosis, abdominal pain, decreased skin turgor.

Diagnosis: Increased hematocrit value, plasma albumin and creatinine levels and Urine osmolarity and specific gravity is 450mOsm/L or >1.015 spec

- **Treatment:** Minor hypovolemia from a known cause that has been completely controlled may be countered with initial rest for up to half an hour. Oral fluids that include moderate sugars and **electrolytes** are needed to replenish depleted sodium ions
- If the hypovolemia was caused by medication, the administration of antidotes may be appropriate but should be carefully monitored to avoid shock or the emergence of other pre-existing conditions
- **Fluid replacement** is beneficial in hypovolemia of stage-2, and if necessary in stage-3 and-4. **Blood transfusions** coupled with surgical repair are the definitive treatment for hypovolemia caused by **trauma**.

Hypervolemia

- Hypervolemia, or fluid overload, is the medical condition where there is too much fluid in the blood.

Causes: Excessive sodium or fluid intake: IV therapy, blood transfusion reactions, High intake of sodium.

Sodium or water retention: Heart failure, Liver cirrhosis, Nephrotic syndrome, Corticosteroid therapy, Hyperaldosteronism, Low protein intake.

Fluid shift into the intravascular space: Fluid remobilization after burn treatment, Administration of hypertonic fluids, e.g. mannitol or hypertonic saline solution, Administration of plasma proteins, such as albumin

Symptoms: Peripheral oedema, scites, dyspnea, PND, confusion, coma, oedema of chest, abdomen and lower legs.

Complications: Congestive heart failure, hypervolemic hyponatremia, pulmonary oedema

Diagnosis: Medical Interview:

Laboratory Tests like CBC, Serum urea, creatinine and electrolytes: Urinalysis, Glomerular Filtration Rate (GFR), Liver function tests : To assess protein and albumin levels.

Imaging studies; ECG: Chest X-Ray: Further investigations.

Hypervolemia Differential Diagnosis;

Pneumonia, Pulmonary embolism (without added lung sounds), Acute anaphylaxis may lead to wheezing, swollen tongue or lips, Bronchospasm, Basal lung crackles, Fine inspiratory crackles

Treatment: Reversion fluid intake, Diuresis therapy

Electrolytes are present in the human body, and the balance of the electrolytes in our bodies is essential for normal function of our cells and our organs.



electrolytes at work

Sodium

- Sodium is an essential nutrient that regulates blood volume, blood pressure, osmotic equilibrium and pH.
- The minimum physiological requirement for sodium is 500 milligrams per day. If the sodium level falls too low, it's called **hyponatremia**; If it gets too high, it's called **hypernatremia**
- In addition to regulating total volume, the **osmolarity** (the amount of solute per unit volume) of body fluids is also tightly regulated. Extreme variation in osmolarity causes cells to shrink or swell, damaging or destroying cellular structure and disrupting normal cellular function.

| Sodium imbalances | Definition | Risk factors/ etiology | Clinical manifestation | Laboratory findings | management |
|---------------------|---|--|---|---|---|
| Hyponatremia | It is defined as a plasma sodium level below 135 mEq/ L | <p>Kidney diseases</p> <p>Adrenal insufficiency</p> <p>Gastrointestinal losses</p> <p>Use of diuretics (especially with low sodium diet)</p> <p>Metabolic acidosis</p> | <ul style="list-style-type: none"> •Weak rapid pulse •Hypotension •Dizziness •Apprehension and anxiety •Abdominal cramps •Nausea and vomiting •Diarrhea •Coma and convulsion •Cold clammy skin •Finger print impression on the sternum after palpation •Personality change | <ul style="list-style-type: none"> •Serum sodium less than 135mEq/ L • serum osmolality less than 280mOsm/kg •urine specific gravity less than 1.010 | <ul style="list-style-type: none"> •Identify the cause and treat *Administration of sodium orally, by NG tube or parenterally *For patients who are able to eat & drink, sodium is easily accomplished through normal diet. *For those unable to drink Ringer's lactate solution or isotonic saline [0.9%NaCl]is given *For very low sodium 0.3%NaCl may be indicated *water restriction in case of hypervolaemia |

| Sodium imbalance | Definition | causes | Clinical manifestation | Lab findings | management |
|----------------------|--|---|--|--|---|
| Hypernatremia | It is defined as plasma sodium level greater than 145mEq/L | <ul style="list-style-type: none"> *Ingestion of large amount of concentrated salts *Iatrogenic administration of hypertonic saline IV *Excess aldosterone secretion | <ul style="list-style-type: none"> • Low grade fever • Postural hypertension • Dry tongue & mucous membrane • Agitation • Convulsions • Restlessness • Excitability • Oliguria or anuria • Thirst • Dry & flushed skin | <ul style="list-style-type: none"> *high serum sodium 135mEq/L *high serum osmolality 295 mOsm/kg *high urine specificity 1.030 | <ul style="list-style-type: none"> *Administration of hypotonic sodium solution [0.3 or 0.45%] *Rapid lowering of sodium can cause cerebral edema *Slow administration of IV fluids with the goal of reducing sodium not more than 2 mEq/L for the first 48 hrs decreases this risk *Diuretics are given in case of sodium excess *In case of Diabetes insipidus desmopressin acetate nasal spray is used *Dietary restriction of sodium in high risk clients |

Potassium

- Potassium is a very significant body mineral.
- Potassium ions are necessary for the function of all living cells. Potassium ion diffusion is a key mechanism in nerve transmission.
- Potassium is found in especially high concentrations within plant cells, and in a mixed diet, it is mostly concentrated in fruits.
- Potassium is most concentrated inside the cells of the body. The gradient, or the difference in concentration from within the cell compared to the plasma, is essential in the generation of the electrical impulses in the body that allow muscles and the brain to function.

| Potassium imbalances | Definition | Causes | Clinical manifestation | Lab findings | Management |
|----------------------|--|---|--|--|---|
| Hypokalemia | It is defined as plasma potassium level of less than 3.0 mEq/L | <ul style="list-style-type: none"> *Use of potassium wasting diuretic *diarrhea, vomiting or other GI losses *Alkalosis *Cushing's syndrome *Polyuria *Extreme sweating *excessive use of potassium free Ivs | <ul style="list-style-type: none"> *weak irregular pulse *shallow respiration *hypotension *weakness, decreased bowel sounds, heart blocks, paresthesia, fatigue, decreased muscle tone intestinal obstruction | <ul style="list-style-type: none"> * K – less than 3mEq/L results in ST depression, flat T wave, taller U wave * K – less than 2mEq/L cause widened QRS, depressed ST, inverted T wave | <p>Mild hypokalemia[3.3to 3.5] can be managed by oral potassium replacement</p> <p>Moderate hypokalemia *K-3.0to 3.4mEq/L need 100to 200mEq/L of IV potassium for the level to rise to 1mEq/</p> <p>Severe hypokalemia K-less than 3.0mEq/L need 200to 400 mEq/L for the level to rise to 1 mEq/L *Dietary replacement of potassium helps in correcting the problem[1875 to 5625 mg/day]</p> |

| | Definition | Causes | Clinical manifestation | Lab findings | Management |
|---------------------|--|--|--|---|--|
| Hyperkalemia | It is defined as the elevation of potassium level above 5.0mEq/L | Renal failure , Hypertonic dehydration, Burns& trauma Large amount of IV administration of potassium, Adrenal insufficiency Use of potassium retaining diuretics & rapid infusion of stored blood | Irregular slow pulse, hypotension, anxiety, irritability, paresthesia, weakness | *High serum potassium 5.3mEq/L results in peaked T wave HR 60 to 110 *serum potassium of 7mEq/L results in low broad P-wave *serum potassium levels of 8mEq/L results in no arterial activity[no p-wave] | *Dietary restriction of potassium for potassium less than 5.5 mEq/L *Mild hyperkalemia can be corrected by improving output by forcing fluids, giving IV saline or potassium wasting diuretics *Severe hyperkalemia is managed by 1.infusion of calcium gluconate to decrease the antagonistic effect of potassium excess on myocardium 2.infusion of insulin and glucose or sodium bicarbonate to promote potassium uptake 3.sodium polystyrene sulfonate [Kayexalate] given orally or rectally as retention enema |

Calcium

- Calcium is an important component of a healthy diet and a mineral necessary for life. Calcium plays an important role in building stronger, denser bones early in life and keeping bones strong and healthy later in life.
- Approximately 99 percent of the body's calcium is stored in the bones and teeth. The rest of the calcium in the body has other important uses, in neurotransmitter release, and muscle contraction.
- **Calcitonin, which promotes bone growth and decreases calcium levels in the blood, and parathyroid hormone, which does the opposite. Calcium is bound to the proteins in the bloodstream, so the level of calcium is related to the patient's nutrition as well as the calcium intake in the diet. Calcium metabolism in the body is closely linked to magnesium levels. Often, the body's magnesium status needs to be optimized before the calcium levels can be**

| Calcium imbalances | Definition | Causes | Clinical manifestation | Lab findings | Management |
|---------------------|--|--|--|---|--|
| hypocalcemia | It is a plasma calcium level below 8.5 mg/dl | <ul style="list-style-type: none"> •Rapid administration of blood containing citrate, •hypoalbuminemia, •Hypothyroidism , •Vitamin deficiency, •neoplastic diseases, •pancreatitis | <ul style="list-style-type: none"> •Numbness and tingling sensation of fingers, •hyperactive reflexes, • Positive Trousseau's sign, positive Chvostek's sign , •muscle cramps, •pathological fractures, •prolonged bleeding time | Serum calcium less than 4.3 mEq/L and ECG changes | <ol style="list-style-type: none"> 1.Asymptomatic hypocalcemia is treated with oral calcium chloride, calcium gluconate or calcium lactate 2.Tetany from acute hypocalcemia needs IV calcium chloride or calcium gluconate to avoid hypotension bradycardia and other dysrhythmias 3.Chronic or mild hypocalcemia can be treated by consumption of food high in calcium |

| Calcium imbalance | Definition | Causes | Clinical manifestation | Lab findings | Management |
|-------------------|--|---|---|--|---|
| Hypercalcemia | It is calcium plasma level over 5.5 mEq/l or 11mg/dl | <ul style="list-style-type: none"> •Hyperthyroidism, •Metastatic bone tumors, •Paget's disease, •osteoporosis, •prolonged immobilisation | <ul style="list-style-type: none"> •Decreased muscle tone, •anorexia, •nausea, vomiting, •weakness, lethargy, •low back pain from kidney stones, •decreased level of consciousness & cardiac arrest | <ul style="list-style-type: none"> •High serum calcium level 5.5mEq/L, • x- ray showing generalized osteoporosis, •widened bone cavitation, •urinary stones, •elevated BUN 25mg/100ml, •elevated creatinine 1.5 mg/100ml | <ol style="list-style-type: none"> 1. IV normal saline, given rapidly with Lasix promotes urinary excretion of calcium 2. Plicamycin an antitumor antibiotic decreases the plasma calcium level 3. Calcitonin decreases serum calcium level 4. Corticosteroid drugs compete with vitamin D and decrease intestinal absorption of calcium 5. If cause is excessive use of calcium or vitamin D supplements reduce or avoid the same |

Phosphate

- Importance: intracellular metabolism of proteins, fats, and carbohydrates
- Major component in phospholipid membranes, RNA, nicotinamide diphosphate, cyclic adenine, phosphoproteins, formation of energy bonds in atp, important acid base buffer.

HYPOPHOSATEMIA

- Decreased phosphate levels in the body.
- **Etiology:** decreased intake, increased renal loss, alcoholism, malnutrition.
- **Drugs:** calcitonin, glucagon, beta adrenergic stimulants thiazide and loop diuretics.
- **Symptoms:** muscle weakness, paresthesia, hemolysis, platelet dysfunction, cardiac and respiratory failure, encephalopathy, confusion and seizure.
- **Treatment:** Na or k-phosphate i.v or oral 0.005-0.06m

HYPERPHOSPHATEMIA

- Increased phosphate levels in the body.
- Etiology: renal dysfunction, $\text{gfr} < 25 \text{ ml/min}$.
Chemotherapy for leukemia or lymphoma
hyperthyroidism.
- Signs and symptoms: renal osteo dystrophy,
decreased phosphate clearance, calcium phosphate
deposition in soft tissue.
- Treatment: dextrose and insulin, hemodialysis

Chloride

- Chloride is the major extracellular anion and contributes to many body functions includes
- Maintenance of osmotic pressure, acid-base balance, muscular activity, and the movement of water between fluid compartments.
- It is associated with sodium in the blood and was the first electrolyte to be routinely measured in the blood. Chloride ions are secreted in the gastric juice as hydrochloric acid, which is essential for the digestion of food.

HYPOCHLOREMIA

- Reduced chloride levels in the body
- **Etiology:** vomiting, alcoholism, loop or thiazide diuretics, hyponatremia.
- **Treatment:** increased NaCl intake , decreased diuretic dosage

HYPERCHLOREMIA

- Reduced chloride levels in the body
- **Etiology:** drugs like corticosteroids, guanethidine, NSAIDS, acetazolamide, metabolic acidosis, hypernatremia.
- **Treatment:** electrolyte free water replacement, diuretics

Uric acid

- End product of purine metabolism.
- Elevated serum uric acid (hyperuricemia) levels due to decreased rate of excretion, leading to deposition of mono sodium urate in tissues and joints precipitating acute attack of gouty arthritis
- Hypouricemia increases Cu in body and in women excess loss of blood during menstruation takes place.

Magnesium

- Magnesium(Mg) is an often forgotten electrolyte that is involved with a variety of metabolic activities in the body, including relaxation of the smooth muscles that surround the bronchial tubes in the lung, skeletal muscle contraction, and excitation of neurons in the brain. Magnesium acts as a cofactor in many of the body's enzyme activities.
- Magnesium levels in the body are closely linked with sodium, potassium, and calcium metabolism; and are regulated by the kidney. Magnesium enters the body through the diet, and the amount of the chemical that is absorbed depends upon the concentration of magnesium in the body. Too little magnesium stimulates absorption from the intestine, while too much decreases the absorption

HYPOMAGNESEMIA

Hypomagnesemia, too little magnesium in the blood stream, may occur because of many reasons. Some have to do with dietary deficiencies, inability of the intestine to absorb the chemical, or due to increased excretion. Common causes of low magnesium include alcoholism and its associated malnutrition, chronic diarrhea, and medications like diuretics (water pills used to control high blood pressure). More than half of hospitalized patients in ICUs may become magnesium deficient. Symptoms involve the heart with rhythm abnormalities, muscles with weakness and cramps, and the nervous system, potentially causing confusion, hallucinations, and seizures.

HYPERMAGNESEMIA

Hypermagnesemia describes too much magnesium in the blood stream and most often occurs in patients with **kidney function** problems in which the excretion of magnesium is limited. In these patients, too much **magnesium intake** in the diet or from magnesium-containing medications like **milk of magnesia** or Maalox may cause elevated magnesium levels

- Since the absorption and excretion of magnesium is linked to other electrolytes, other diseases may be associated with high magnesium levels, including diabetic ketoacidosis, adrenal insufficiency, and hyperparathyroidism. Hypermagnesemia is often associated with hypocalcemia (low calcium) and hyperkalemia (high potassium).
- Symptoms can include heart rhythm disturbances, muscle weakness, nausea and vomiting, and breathing difficulties.

Bicarbonate

- This electrolyte is an important component of the equation that keeps the acid-base status of the body in balance.
- Water + Carbon Dioxide = Bicarbonate + Hydrogen
- The lungs regulate the amount of carbon dioxide, and the kidneys regulate bicarbonate (HCO_3)
- This electrolyte helps buffer the acids that build up in the body as normal byproducts of metabolism. For example, when muscles are working, they produce lactic acid as a byproduct of energy formation. HCO_3 is required to be available to bind the hydrogen released from the acid to form carbon dioxide and water. When the body malfunctions, too much acid may also be produced (for example, diabetic ketoacidosis, renal tubular acidosis) and HCO_3 is needed to try to compensate for the extra acid production.

Reference:

- Laboratory interpretations-L.Scott
- www.Wikipedia.com

Thank you