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ELECTROLYTES AND BLOOD GASES

27.1 INTRODUCTION

Electrolytes are charged particles (ions) dissolved in the various fluid compartments of the body (intravascular, interstitial, and intracellular) and perform a variety of functions in the human body. The electrolytes of importance at this point in the course are: (1) Sodium; (2) Potassium; (3) Calcium; (4) Hydrogen; and (5) Bicarbonate. Since hydrogen and bicarbonate ions are primarily involved in pH balance, they are discussed separately.

Sodium, potassium and calcium will be considered here. Sodium is primarily an extracellular ion, that potassium occurs primarily intracellularly, and that calcium performs a variety of functions.

27.2 SODIUM

Sodium is the major extracellular cation. In general, sodium balance defines water balance.

- Na^+ is the most abundant electrolyte in the body Transmission and conduction of nerve impulses
- Responsible for osmolality of vascular fluids
- Regulation of body fluid levels
- Sodium shifts into cells and potassium shifts out of the cells (sodium pump)
- Assists with regulation of acid-base balance by combining with Cl^- or HCO_3^- to regulate the balance



Notes

Abnormalities

Hyponatremia: Excessive sodium loss or H₂O gain

Causes

- Prolonged diuretic therapy
- Insufficient Na intake
- GI losses – suctioning, laxatives, vomiting
- Administration of hypotonic fluids
- Alcoholism

Hypernatremia: occurs with excess loss of H₂O or excessive retention of Na. Can lead to death if not treated

Causes

- Vomiting/diarrhea
- Inadequate AntiDiuretic Hormone
- Major burns

27.3 POTASSIUM

Potassium is the most abundant cation in the body cells. About 97% is found in the intracellular fluid. Normal extracellular K⁺ is 3.5-5.3mEq/L. A serum K⁺ level below 2.5 or above 7.0 can cause cardiac arrest

Functions

- Essential for normal membrane excitability for nerve impulse
- Promotes conduction and transmission of nerve impulses
- Contraction of muscle
- Promotes enzyme action
- Assist in the maintenance of acid-base

Abnormalities**Hypokalemia****Causes**

- Prolonged diuretic therapy

- Inadequate intake
- Gastric suctioning, laxative use, vomiting
- Excess insulin
- Hepatic disease
- Lower Potassium concentration dramatically affects excitable membrane function of muscle and nerve. Levels < 3 produce marked neuromuscular symptoms

**Notes**

Hyperkalemia

Causes

- Shock, severe hemolysis, tumor lysis, burns (cellular release)
- Renal failure (decreased excretion)
- Endocrine diseases with mineralocorticoid deficiency
- “Potassium sparing” diuretics
- Acidosis (K exits cells in exchange for H)
- Artifactual hemolysis of blood specimens; K leak in chilled or unprocessed specimens

Symptoms

- Greater than 5.0, EKG changes, decreased pH
- Acts as myocardial depressant; decreased heart rate, cardiac output
- Symptoms: muscle weakness, nausea, lethargy, arrhythmias, characteristic EKG changes, cardiac arrest, GI hyperactivity
- levels > 7.5 produce symptoms and levels > 10 are lethal

27.4 CHLORIDE

The major extracellular anion (expected, 118 - 132 meq/l in serum)

Function

- Important in water distribution, osmotic pressure, and anion-cation balance
- Cl⁻: regulates osmotic pressure and assists in regulating acid-base balance. Maintains serum osmolality along with Na⁺
- Helps to maintain acid/base balance

MODULE

Biochemistry

Electrolytes and Blood Gases



Notes

- Combines with other ions for homeostasis; sodium, hydrochloric acid, potassium, calcium
- Closely tied to Na^+
- Decreased level is most commonly due to GI losses
- Found in ECF
- Changes the serum osmolality
- Along with Na^+ causes retention of water
- Assists with regulation of acid-base balance
- Cl^- combines with hydrogen ion to form hydrochloric acid in the stomach

Abnormalities

Hypochloremia

Causes

- Fluid volume expansion (dilution)
- Renal diseases (reabsorption failure)
- Metabolic acidosis with increased “unmeasured anions” (e.g. DKA)
- SIADH
- GI loss (protracted vomiting)

Hyperchloremia

Causes

- Dehydration
- Renal tubular acidosis, acute renal failure
- Bicarbonate loss (diarrhea)
- Mineralocorticoid excess (Cushing’s syndrome and hyperaldosteronism)
- Diabetes insipidus

27.5 CALCIUM

Ca^{2+} : usually combined with phosphorus to form the mineral salts of bones and teeth, promotes nerve impulse and muscle contraction/relaxation.

Abnormalities

Hypocalcemia:

Causes

- Abnormalities of the parathyroid gland
- Inadequate intake
- Excessive losses.

Symptoms

- Can cause skeletal and neuromuscular abnormalities
- Impairs clotting mechanisms
- Affects membrane permeability
- Diagnostic findings:
 - EKG changes
 - Serum Ca^{++} levels < 8.5 mg/dL
 - Prolonged PT and PTT

Hypercalcemia

- Increased serum levels of Ca^{++}
- Symptoms are directly related to degree of elevation
- Clients with metastatic cancer are especially at risk

Causes

- Excessive intake
- Excessive use of antacids with phosphate-binding
- Prolonged immobility
- Excessive vitamin D intake
- Thiazide diuretics
- Cancer
- Thyrotoxicosis

27.6 MAGNESIUM

- Mg^{2+} plays role in carbohydrate and protein metabolism, storage and use of intracellular energy and neural transmission.
- Important in the functioning of the heart, nerves, and muscles



Notes



Notes

At a glance

- Hyponatremia (sodium deficit < 130mEq/L)
- Hypernatremia (sodium excess >145mEq/L)
- Hypokalemia (potassium deficit <3.5mEq/L)
- Hyperkalemia (potassium excess >5.1mEq/L)
- Chloride imbalance (<98mEq/L or >107mEq/L)
- Magnesium imbalance (<1.5mEq/L or >2.5mEq/L)

27.7 BLOOD GAS TESTING

- Blood gas analysis may be carried out in a main laboratory, in an ER or OR lab or using POC devices.
- Provides accurate measurement of PO₂, PCO₂, pH, hemoglobin saturation, bicarbonate and hematocrit (some analyzers also offer electrolytes, lactate, glucose, Hgb, CO-Hgb, met- and sulfHgb).
- Arterial blood, drawn in appropriate equipment and transported quickly (10 - 15 min) on ice to the lab.
- Check ulnar artery patency before withdrawing blood from radial artery .
- “Arterialized capillary blood” (warmed heel or earlobe) may be acceptable in some Cases.
- Specimen is accompanied by history with FIO₂ and clinical status of patient, and patient temperature (all are important for interpretation and are included in the returned report).
- Erroneous results from room temp specimens and specimens with air bubbles or improper capping.



TERMINAL QUESTIONS

1. Enumerate in detail the functions of the electrolytes Sodium and Potassium and also describe the related abnormalities.
2. What is hypochloremia? Write down the causes.
3. What is hypokalemia? List out the causes and symptoms.
4. What is hypocalcemia? Write briefly on causes and symptoms of hypocalcemia.
5. List out the uses of blood gas analysis.
6. Normal levels of serum Calcium is.....
7. Hyponatremia is defined as when levels of sodium falls below.....
8. artery blood sample is used for blood gas analysis.