FLUID & ELECTROLYTES

Fluid Compartments

Intracellular = fluid inside of the cell 40% of body weight 70% of body water

Extracellular = fluid outside the cell found in three compartments 20% of body water

Interstitial Fluid-in between cells and the tissue (third space) moved by reabsorption into blood vessels and lymph vessels 15% of body weight

Intravascular Fluid (plasma)-Fluid in the blood vessels 5% of body weight

Lymph Fluid- Inside of the lymph vessel aid in returning fluid to the circulatory system

Components of Extracellular fluid

Proteins and Fats too big to enter blood vessels
Ions such as Na+, Cl- or H+
Nutrients and H2O
Dissolved Gases

Water Balance

Daily Loss Input = Output - loss
Lungs, skin, kidney and large intestines (insensible losses) – hard to measure.
Kidney output = urine (should be 0.5ml/kg per hour.
Decrease in water leads to dehydration, often reflected in loss of blood volume
Increase leads to water intoxication – fluid overload
One liter of water =2.2 lbs or 1kg.
Sudden weight gain or loss can indicate fluid shift

Normal values€↑

Blood osmolality 285mOsm/kg – 295 mOsm/kg

An increase can result from dehydration – think high and dry
A decrease can result from fluid overload or excessive intravascular fluid – think low – below Below sea level, therefore wet.

Regulators

Hypothalamus monitors osmotic pressure (ratio of solute particles to solvent water/fluid) an increase in osmotic pressure
leads to thirst
ADH -reabsorbs water from the filtrate (urine) in the kidneys keeping the fluid in the body decreasing osmotic pressure
Aldosterone-reabsorbs Na+ from the filtrate (urine) keeping the Na+ in the body increasing the osmotic pressure (remember aldosterone and cortisol are steroids so when a client is on steroids they may retain Na+ and become hypernatremic) Water follows Na+ so ↑ in Na+ reabsorption in kidneys = ↑ water reabsorption as well.

Processes of movement

Water tends to stay in the compartment where the electrolytes (solutes) are the most concentrated often in the area of the highest Na+ concentration (Water follows salt)

Solutions: ratio of solvent (water part) to solute (solid part)

Isotonic- of the same concentration 5% Glucose & 0 .9% NaCl LR - Lactated Ringers
Hypotonic- of below concentration WATER, 0. 45% NaCl,
Hypertonic- of above concentration 50% Glucose, 3% normal saline

Note: D5W (5% glucose) is isotonic but once once it gets into the pipes/blood vessels the body rapidly uses the glucose leaving free water, inside the pipes which is then hypotonic.

Diffusion

Movement of a substance such as a solute from an area of high concentration to an area of low concentration (Down the concentration gradient)

Facilitated Diffusion

Movement of a substance such as a solute from area of high concentration to an area of low concentration with the aid of a carrier molecule or hormone such as the relationship of glucose and insulin. Insulin carrys the glucose into the cells

Active Transport – Requires energy (ATP) to move solutes against the concentration gradient. The Na/K+ pump is a great example - during depolarization Na rushes into the cell and K+ rushes out. During repolarization , Na+ is pumped back outside the cell and K+ inside the cell, reestablishing cell electrical neutrality.

Osmosis

Movement of water (solvent) from an area of high concentration (of solutes) to an area of low concentration Water travels to an area of higher solute concentration - it is pulled there Water tends to stay in the compartment where the electrolytes are the most concentrated often in the area of the highest Na+ concentration. **Remember Water follows salt**

Colloid Osmotic Pressure

The pressure exerted by solute components of solution on a membrane. An increase in the solutes leads to an increase in the osmotic pressure. Think dehydration makes blood thicker or more viscous and will pull H2O to the area of higher solute concentration.

Oncotic Pressure

The pressure exerted by colloids in the solution, Think plasma proteins in the blood, oncotic pressure is greatest in the blood and less in the interstitial spaces When thinking about oncotic pressure the main plasma protein will be albumin which will maintain the oncotic pressure of the blood. Albumin is produced by the liver, so if the liver is compromised the oncotic pressure of the blood will decrease.

Hydrostatic Pressure

The pressure exerted by fluid components of a solution on a membrane. An increase in the fluids leads to an increase in the hydrostatic pressure. Think of filtration in the kidneys, an increase leads to a higher GFR and a decrease leads to lower GFR. Also the position of the body can change the hydrostatic pressure in a certain portion, such as if the legs are in a dependent position the hydrostatic pressure will increase in the legs causing the fluid to shift from the vascular to the interstitial leading to edema

Movement of solutes:

On the arterial end of a capillary the hydrostatic pressure is greater then the colloid osmotic pressure forcing solutes out of the capillary into the extracellular space. On the venous end the opposite is true, pulling solutes back into the capillary.

Protein metabolism and fluid: Normal BUN 10-20 mg/dl Normal Creatinine 0.6-1.2 mg/dl

Increase in Blood urea nitrogen (BUN) means an increase in protein metabolism which could be due to crushing injuries, burns, or other traumas. An increase in serum creatinine would reflect a decrease in kidney function. Urine becomes closer to plasma and the influence of diet will be seen to have a more direct affect on the urine

Plasma to Interstitial

Elevation of venous hydrostatic pressure

A disorder which causes the blood to back up in the veins pushes the fluid out of the capillaries into the tissues. Examples right side CHF, liver failure, and also physical obstructions such as tourniquets, restrictive clothing, obesity, or blood clot.

Decrease in plasma oncotic pressure

If plasma proteins decrease in the blood than fluid in the 2nd and 3rd space will not be drawn back into the blood vessel and will stay in the tissues or cavities. Examples nephrotic syndrome

(proteins leak into the urine out of the blood), liver disorders or malnutrition Fluid that extravasates or leaks out of pipes into the interstitial space = edema. Fluid the leaks into a cavity or abnormal space = third spacing: Ascites (pericardial effusion)

Interstitial to Plasma

Most often influenced by administering IV Therapy by introducing a hypertonic solution such as albumin, or Mannitol to shift or pull fluid back to the intravascular space (back to the blood inside the pipes). Also decreasing the amount of fluid in the blood, think diuretics or hypovolemic shock maybe caused by diarrhea or vomiting.

Electrolytes

NA+ (SODIUM) 135 -145 mEq/L

Function: Most abundant extracellular ion. Function in the generation of action potential in skeletal muscle and nervous tissue. Maintains osmotic pressure of the ECF. Amount of Na+ regulates water balance and blood pressure. Controlled by ADH, aldosterone and ANP (atrial naturetic peptide)

Foods high in sodium: processed/canned, broth, vegetable juices, and celery

HYPONATREMIA <135 mEq/L

Cause: Loss of NA+ through sweat, vomiting, diarrhea, diuretic or burns. True excess of water as in SIADH or renal failure. Also seen in when cells begin to lyse increasing extracellular K+. Excess of dextrose IV solutions or fluid replacement with water (ice chips).

Symptoms: Weight gain, muscle weakness, tachycardia but weak pulse & shock. Mental confusion and anxiety due to increase water in CNS, (Brain cells swell) stupor and coma may result.

HYPERNATREMIA >145 mEq/L or osmolarity >295 mOsm/Kg

Cause**:** Increase in Na+ in the ECF due to dehydration or decrease of water intake. Also Na+ gain in diet, medication or through IV solution. Caused by polyuria such as with Diabetes mellitus, also seen in burns and in Cushing disease. Osmotic diuretics and mechanical ventilation may lead to H2O loss without Na+ loss.

Symptoms: Intense thirst, poor skin turgor, overall weakness, and lethargy. Finally renal failure or coma may result from to cellular dehydration. (Brain cells shrink)

POTASSIUM K+ 3.5-5.0 mEq/L

Function: Most abundant intracellular ion needed for the repolarization of action potential in skeletal muscle and nervous tissue, also maintains osmotic pressure. Helps in the pH balance. Controls blood pressure through the secretion of aldosterone (Increase of K+ leads to increase of Aldosterone). NOTE: K+ is not stored by the body; freely excreted by kidneys

Foods High in K+: bananas, pears, potatoes, tea, colas and fruit juices

HYPOKALEMIA <3.5 mEq/L

Cause: Increase of Na+, vomiting, diarrhea, use of some diuretics, IV insulin or glucose, and kidney disease. Also seen in cases of excessive Aldosterone as in adrenal tumor or Cushing's disease.

Symptoms: Muscular weakness, increased urine output, depressed respirations, vomiting and coma. Decreases reflexes and Blood pressure. Cardiac dysrhythmias such as bradycardia, AV block decreased T wave and prolonged QRS Note: Will enhance the effects of Digitalis and may cause toxicity.

HYPERKALEMIA >5.0 mEq/L

Cause: Increase of K+ in the blood due to cellular traumas in burns and MI. Also seen Addison's disease, insulin deficiency, hemorrhagic shock and intestinal obstruction.

Symptoms: Muscular weakness, respiratory difficulty, irritability, diarrhea, and coma. Cardiac dysrhythmias such as heightened T wave and shortened QRS heart may lead to cardiac arrest

CALCIUM CA+ 8.5 -10.5 mg/dl

Function: Plays a role in release of neurotransmitters, blood coagulation, maintains muscle tone and muscle contraction Essential in heart and brain functions.

Foods rich in Ca+ - milk, cheese, broccoli and meat.

HYPOCALCEMIA

Cause: Cause for Ca+ levels to drop include: inability to convert vitamin D, an increase of serum phosphorous, overuse of enemas and laxatives, sepsis burns, chronic malabsorption syndromes, and chronic renal failure. Hypoparathyroidism decrease in Ca+ level in blood causes an increase in PTH, this leads to the demineralization of the bone, and finally bone fractures. Also the citrate used in stored blood can bind Ca+ in multiple transfusions

Symptoms: Numbness in the fingers and the toes, bradycardia, altered blood clotting, hyperreflexive muscles and cramps, tetany, tonic seizures, and convulsions. Think Chevostek and Trousseaus signs

HYPERCALCEMIA

Cause: Hyperparathyroidism, vitamin D overdose and tumor of stomach, kidney, lung or bone, indiscriminate use of antacids, and prolong immobility.

Symptoms: Polyuria, kidney stones, muscle weakness heart block/cardiac arrest, digitalis toxicity, vomiting, bone pain, pathological fractures depression, stupor and coma.

MAGNESIUM Mg 2+ 1.5-2.5 mEq/L

Necessary for biochemical reactions – maintains normal muscle and nerve function . Keeps heart rhythms steady, suggests supports immune system and maintains bone strength. Helps regulate blood sugar levels and promotes normal blood pressure.

HYPOMAGNESHIA <1.5 mEq /L – occurs more frequently than hypermagnesia.

Cause: chronic alcoholism is most common cause. Loss from GI tract (NG suction, diarrhea, fistula), pancreatitis, burns, long term use diuretics, aminoglycoside antibiotics.

Symptoms: Nueromuscular irritability with tremors, ↑ reflexes, tremors, convulsions. Positive Chuostek's and Trousseau's sign like with hypercalcemia.

HYPERMAGNESEMIA: > 2.5 mEq/L Abnormal retention as in renal failure, adrenal insufficiency, And treatment with magnesium salts.

Symptoms: Peripheral vasodilation → flushing, N/V, muscle weakness, paralysis, hypotension, bradyochardia, lethargy, drowsiness, respiratory depression, coma, respiratory and cardiac arrest.