Body fluids

Lecture 13:

Body fluids are distributed in compartments:

A. Intracellular compartment: inside the cells of the body (two thirds)
B. Extracellular compartment: (one third) it is divided into sub compartments:
    1. Inside blood vessels (intravascular compartment)→plasma
    2. Inside lymphatic vessels
    3. Transcellular fluid: fluid found around organs in cavities, examples are:
        a. Synovial fluid
        b. Peritoneum fluid
        c. Pericardium fluid
        d. Cerebrospinal fluid: found in the CNS
        e. Pleural fluid
    4. Interstitial fluid: fluid found outside the cells and the vessels

        Rules followed in exchanging fluids:
        1. Osmotic pressure causing osmosis
        2. Hydrostatic pressure causing filtration
        3. Oncotic (colloid osmotic) pressure:

Note: the intravascular fluid contains more proteins than the interstitial fluid, but the intracellular fluid contains the highest amount of proteins.
So what is the importance of that?
Answer: because of the hydrostatic pressure at the level of capillaries (arterial side), filtration of fluids occurs but at the Venous side there is another force attracting back these fluids which is created by proteins (this pressure is called oncotic pressure).

What happens if the concentration of proteins in the plasma is decreased?
There will be normal filtration but the reabsorption won't be efficient so some fluid will remain at the level of interstitial fluid causing Edema.

Conditions with no protein content in plasma:

1. In nephrotic syndrome: at the level of kidney in this syndrome these is a loss of proteins which is called hyperproteinemia
2. In liver diseases: because the liver is the site for synthesizing proteins

* We have high balance of water in the body and this process is related to the sodium homeostasis.

How do we lose water?

1. Urine (60%)
2. Feces, sweating → sensible loss of water
3. Evaporation → insensible
4. Breathing

Note: breathing and evaporation loss of water equals almost 28%

How do we uptake(input) water?

1. Drinking
2. Food
3. Metabolic processes such as burning glucose chemically

What organs are involved in the regulatory process?

Urinary system, cardiovascular system, endocrine, skin,

Aspects of regulation:

1. Osmolality: we have osmoreceptors that sense changes in osmolality and sending signals to the CNS
2. Regulation of extracellular fluid: by sensing the changes in the volume

Ex: loss of hypotonic solution → increase in osmolality in the interstitial fluid → attract water leading to cell shrinking .(called dehydration)

Ex2: if someone ingests high amount of pure water → osmolality decreases →cells swell . (water intoxication)

How to measure the volume of body fluids?

By the dilation principle: C1 V1 =C2 V2

**Characteristics of substances that can be used are mentioned in the slides.

Measuring the total body fluid volume:

We use radioactive water (tritium) or heavy water (deuterium).

Measuring the ECF volume:

We use substances that are distributed only in the ECF examples are:

1. Radioactive sodium (although sodium will be distributed inside the cells but within the first 30 mins only small amount will be distributed so we can ignore its effect) → here we measure the sodium space
2. Inulin → we measure the inulin space
   Note: the inulin space may or may not equal the sodium space.
3. ^{125}I-iodothalamate
4. Thiosulfate

Measuring the ICF volume:

The ICF volume= total volume- ECF volume

Lecture 14:

By the process of centrifugation of blood, we are packing all the cells together which is called PCV (packed cells volume)

So the blood is distributed in these percentages:

Plasma: 55%

Platelets 1% or less

Cells 45%

What is the composition of plasma?

1. Mostly water
2. Small molecules as electrolytes (2%)
3. Proteins: 60-80 g/L mostly, types of proteins found are:
   - Albumin (40-50 g/L) about 54%
   - Globulins (alpha 1 and 2, beta, gama): (20-30 g/L) about 38%
     Note gama globulins are the antibodies
   - Fibrinogen: which is hardened to form the final product for blood clotting (fibrin)

   Ways to separate blood products:

   1. Leaving the blood to coagulate first then centrifuging → fibrinogen is consumed with other coagulation factors → here we have serum along with cells

2. Centrifuging the blood without the process of coagulation →here we have plasma along with cells

So, serum is plasma without fibrinogen

How to measure the plasma volume?

Using something that can't leave vessels →proteins

1. we actually use iodine radioactive albumin and after half an hour we take samples and use the dilation method
2. we can also use" Evans blue"

how to measure the total volume?

1. By labelling the RBCs with Cr-radioactive and by taking a sample and measuring its reactivity we can know the total blood volume
2. We can calculate it by using this equation if we know the plasma volume and the ratio of hematocrit:
   Total volume = plasma volume/(1-hematocrit)

The osmolality is highly regulated By

1. Regulating the sodium concentration (osmolality)

Osmoreceptors sense any change in the osmolality sending these changes towards the CNS which sends signals towards other centers in hypothalamic to activate

the thirst sensation → drinking water.(increasing the input)

In addition, the increase in osmolality leads to an increase in the secretion of ADH (antidiuretic hormone) from the pituitary gland, ADH acts on the kidney causing more reabsorption of water. (decrease the output)

2. Regulating the volume

   How do we sense the volume changes?

   - Any decrease in the volume of ECF will reduce the blood flow towards the kidney, activating another endocrine system called **renin angiotensin aldosterone system:**

   Renal cells (juxtaglomerular cells) can synthesize an enzyme called renin which converts angiotensinogen to angiotensin I, then ling tissue converts angiotensin I to angiotensin II which activates the release of aldosterone from suprarenal gland, aldosterone increases the absorption of sodium and the retention of sodium changes the osmolality causing osmosis and this changing the volume.

   - If there is an increase in volume: the right atrium releases the ANP hormone (atrial natriuretic peptide) which effect is to decrease blood pressure but also is has some other effects to reduce water

and salt and decrease the angiotensin II (indirect effect)

Disorders related to change in volume:

1. Hypervolemia
2. Hypovolemia

Disorders related to change in osmolality:

1. Hyponatremia
2. Hypernatremia

Some examples the Dr mentioned in the lecture:

- Loss of pure water only by decreasing the secretion of ADH → hypovolemia , hypernatremia
- Loss of plasma from the body → hypovolemia , isonatremia
- Ingesting high amount of pure water → hypervolemia , hyponatremia
- Giving someone hypertonic solution → hypervolemia , hypernatremia
- Loss of salts by decreasing aldosterone → hypovolemia , hyponatremia
- Increasing ADH → hypervolemia , hyponatremia
- How can we increase the ECF only with no change in osmolality? by giving normal saline
- Increase both ECF and ICF but decrease osmolality? increase ADH

- Diabetes insipidus السكري الكاذب: decrease in ADH leading to high urination (osmolality increases and volume decreases)
- Increase osmolality and increase ECF but decrease ICF? taking high amount of salts (increases osmolality and causes shifting of water from ICF to ECF)

Good luck ☺

Best wishes ☺

Joud karmi