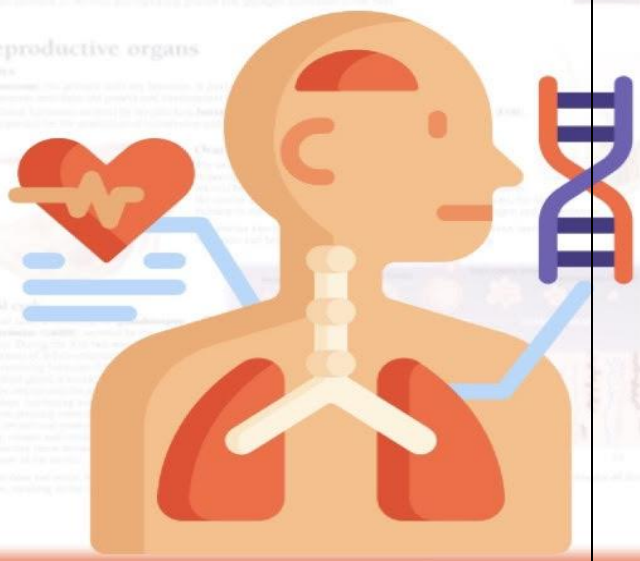
Doctor 022

Physiology

Sheet no. 12



Writer: Sadeel Ma’mon

Corrector:

Doctor: Dr Mohammed khatatbeh

بسم الله الرحمن الرحيم

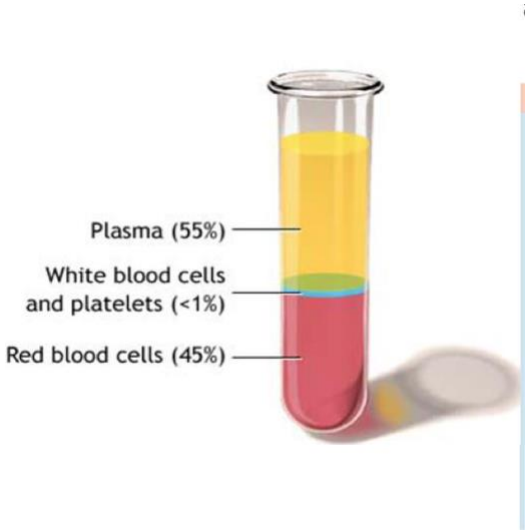
ملاحظة: الكلام باللون الأسود كلام السلايدات+النوتس والشرح التوضيحي ، واللون الأزرق كلام الدكتور.

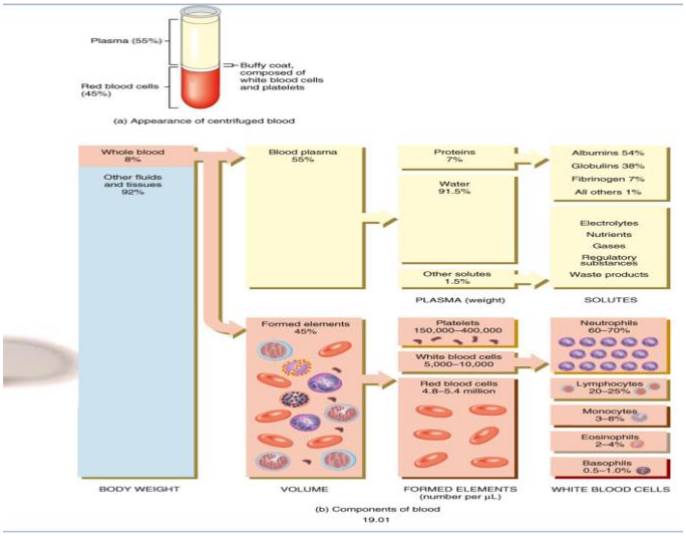
Introduction

As we learned in the previous lecture, the blood is composed of red blood cells (RBC or hematocrit)45%, white blood cells and platelets <1%, and the most abundant component which is plasma 55%.

The plasma is composed of 90% water, and 2% of small molecules such as electrolytes nutriments.

In this lecture we will discuss how our body could control these percentages and deal with any change such as increased plasma volume (ECF volume) and increased osmolality such: increased[Na+].





Topics of this lecture

Notes:

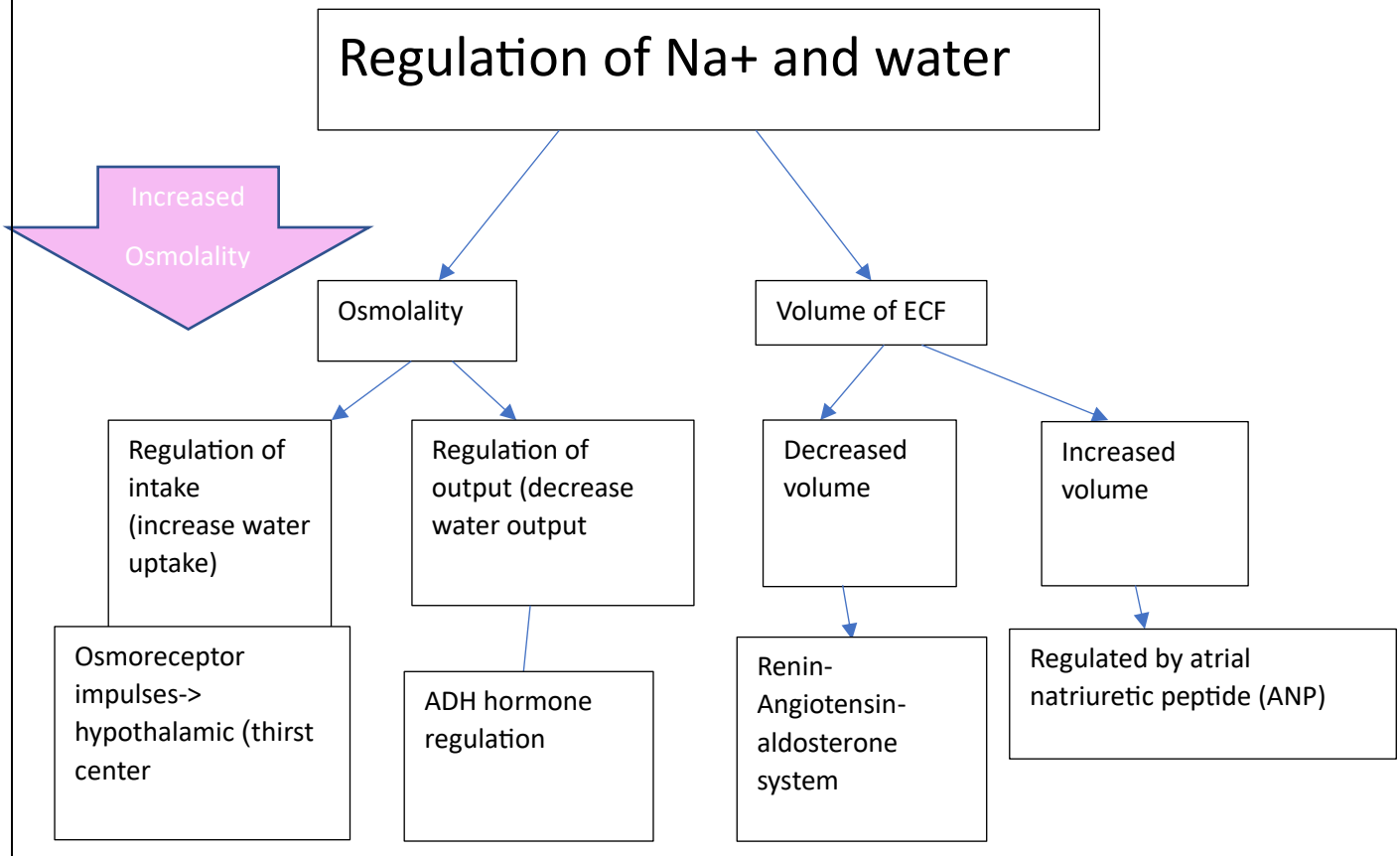
The most abundant protein in plasma is albumin

-serum: is the plasma without the fibrinogen (because is will be consumed in process of blood clotting

In this lecture we will talk mainly about:

1) Regulation of Na+ and water (osmolality and volume of ECF)
2) Disorders of volume
3) Disorders of osmolality
4) Disorders of volumes and osmolality
5) Oedema
6) Safety factors for preventing oedema

Note: for last topic (safety factors) doctor has discussed the first factor only, and said he will send the rest of the lecture online on teams.



Osmoregulation
(Osmolality regulation

-Increased osmolality is treated in two ways:

<u>First :Increase water intake</u>

Quick info:

_this process is regulated by hypothalamic(thirst center)

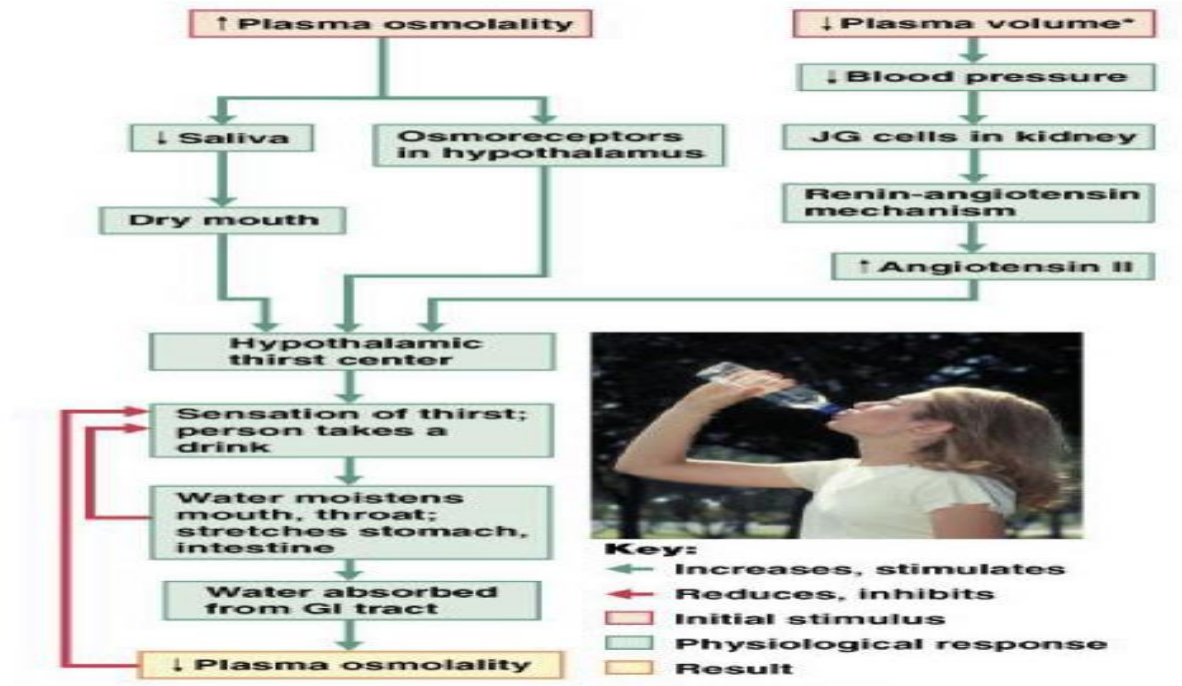
_thirst center responds to osmoreceptor impulses, angiotensin II

Explain:

When plasma osmolality is **high**, osmoreceptors in hypothalamus sends impulses to the hypothalamic thirst center which stimulates sensation of thirst , so the person takes water.

Results:

Decrease plasma osmolality



<u>Second:Decrease water output</u>

Quick info:

_regulated by hypothalamus(**ADH** is released from posterior pituitary)

Explain:

When osmolality is increased by high concentration of Na+ osmoreceptors in hypothalamus is stimulated

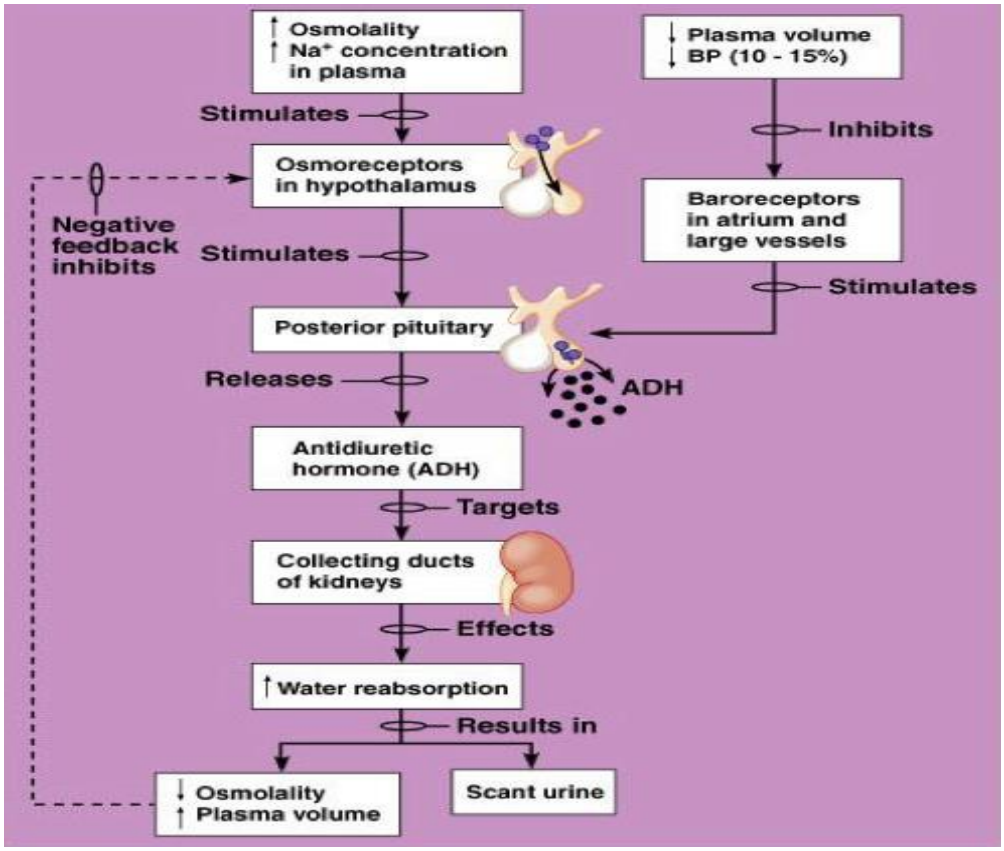
then,posterior pituitary is stimulated and releases Antidiuretic hormone(ADH) which targets collecting ducts of kidney which effects water reapsorption

Results:

1.decreaseing osmolality

2. Increasing plasma volume

3. Scant urine



Regulation volume of ECF (Plasma volume)

It’s depends on Na+ excretion in urine(pay attention: excretion not concentration) and controlled by **renin-angiotensin aldosterone system**

<u>First: Reduced volume :</u>

Quick info:

We use here renin-angiotensin-aldosterone system (stimulation of aldosterone)

Explain:

It’s a regulation of output methods (meaning that we decrease the amount of output water), firstly, when we have low blood pressure (decreased plasma volume), that will stimulates juxtaglomerular cells in kidney to release renin enzyme which : converts the angiotensin inogen which is released from liver to ingiotensin (I), after that the lungs (specifically : surface of pulmonary and renal endothelium) is stimulated by angiotensin (I) to release (ACE) ,which also stimulates the release of angiotensin (II).

Angiotensin (II), (the hero of our story 🦸) have two major functions:

1. Stimulates the adrenal gland cortex(قشرة الغدة الكظرية) to release aldosterone secretions that increase the Na+ absorption and decrease the absorption of K+

2. angiotensin (II) will stimulate the arterior vasoconstriction(انقباض الأوعية) to increase blood pressure

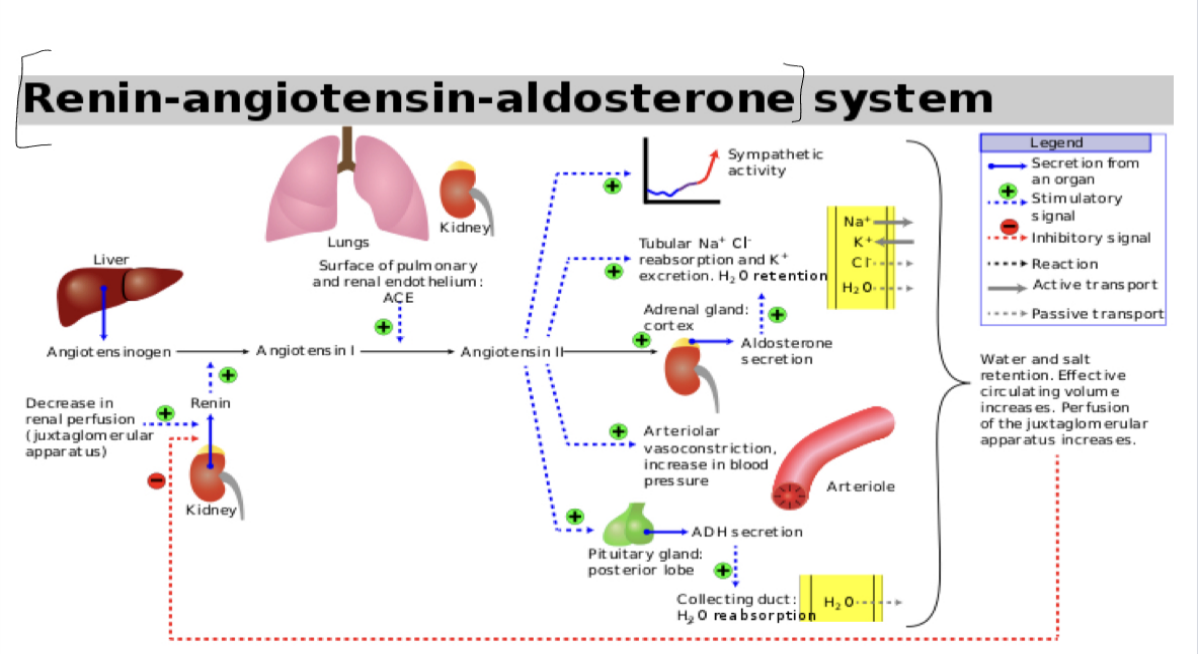
Results :

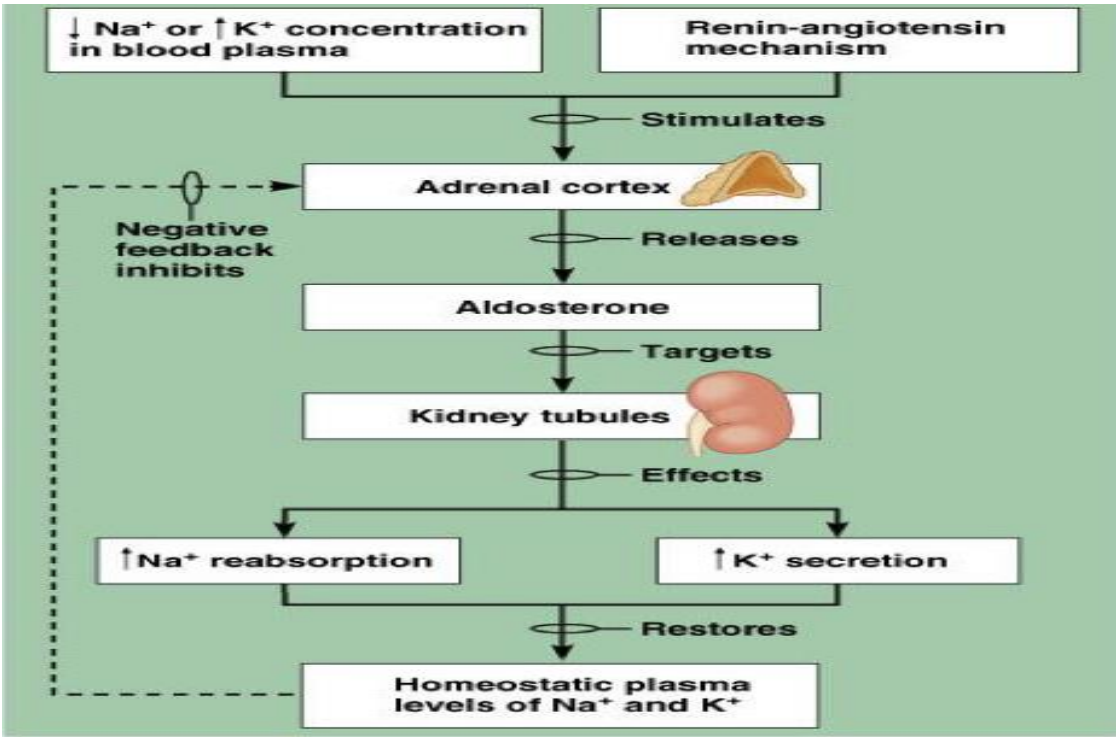
-Increase blood pressure by:

- water retention

- Na+ re absorption

- K+ excretion





Second: increased volume:

Quick info:

-Regulated by atrial natriuretic peptide (ANP)

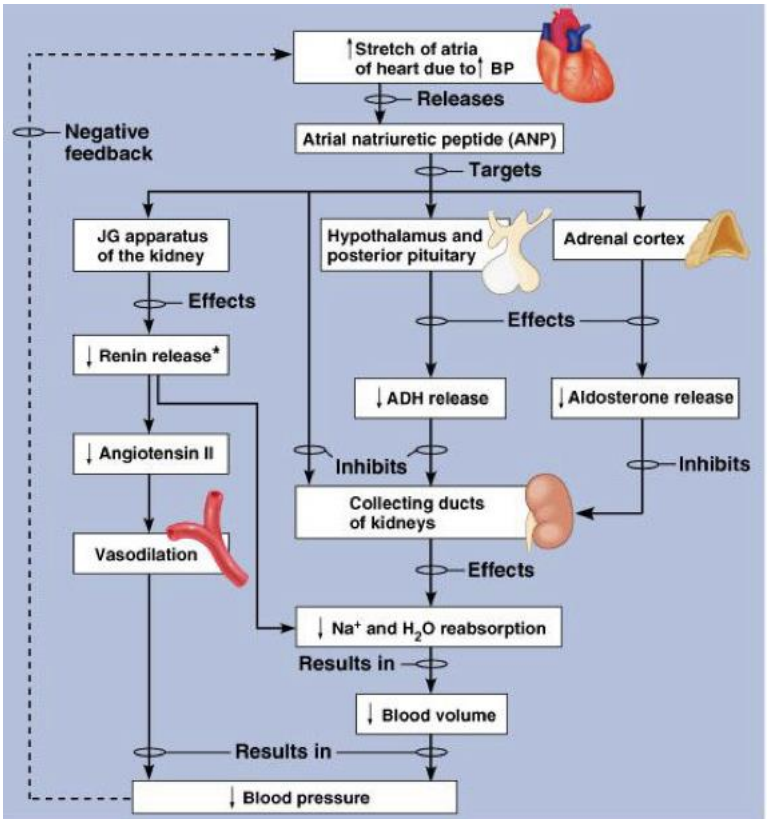
To know more information and understand more, you can watch this video

https://youtu.be/bWZqN1my5sQ

Effects:

-reduces Bp,salts,and water by effects over vessels

-decrease angiotensin (II) and aldosterone secretions.and this mechanism is the opposite of renin-angiotensin-aldosterone mechanism



Disorders of volumes

Hypovolemia

1.Results by excessive loss of fluids.caused by diarrhea, vomiting and blood loss.

2.decreased ADH release can also cause hypovolemia(diabetes insipidus)

Hypervolemia

Results by excessive intake or administration of fluids

-for example if you increase the secretion of ADH you will increase water volume but you will decrease the osmolality. So you can see that there is an overlapping between mechanisms so by effecting one parameter by a certain mechanism you affect the other one by different mechanism

Disorders of Osmolality

Hyponatremia

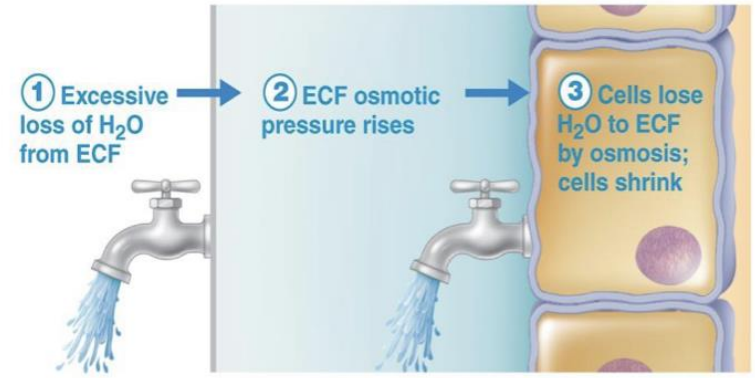
Results by excessive loss of Na+ or administration of hypotonic fluids

2. Can be caused by excessive intake of potable water(ماء نقي

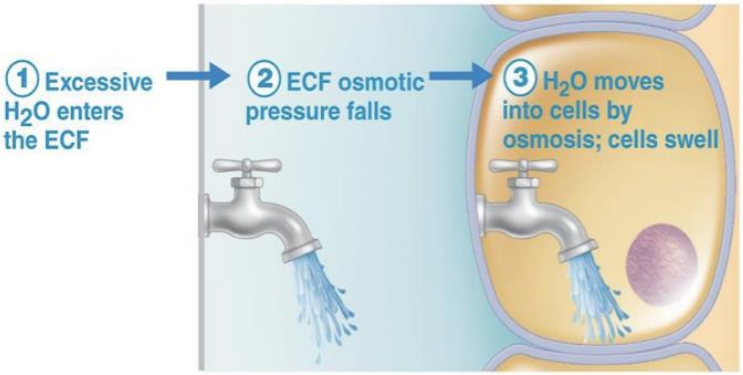
3. Decreased release in aldosterone can cause it

Hypernatremia

Results by excessive intake of Na+ or administration of hypertonic fluids



(a) Consequences of dehydration. If more water than solutes is lost, cells shrink.



(b) Consequences of hypotonic hydration (water gain). If more water than solutes is gained, cells swell.

a.if the cell looses water from ECF the osmotic pressure will increase in ECF (the osmotic pressure is a pulling force toward high concentrated areas or hypertonic area) .then water will move from the cells to the ECF causing the cell shrinkage.

b.if the ECF gains water, the osmotic pressure will decrease ,then osmotic pressure will be higher inside the cell which makes the water move from ECF toward the ICF or the cell, causing the cell swelling.

Remember:

Hydrostatic pressure= pushing force

Osmotic pressure= pulling force

Disorders of Osmolality and volume

These slides are taken from 021 sheet(previous year):

There can be a combination of disorders of volumes and osmolality.

- **Hyponatremia with dehydration** → Hypovolemia

  High loss of water (diarrhea, vomiting or blood loss) and solids, replaced with only drinking hypotonic water.

- **Hyponatremia with overhydration** → Hypervolemia
  - High retention of water (administration).
  - Increased ADH.

  High release of ADH increases the volume and decreases the osmolality.

- **Hypernatremia with dehydration**

  Loss of hypotonic fluid.

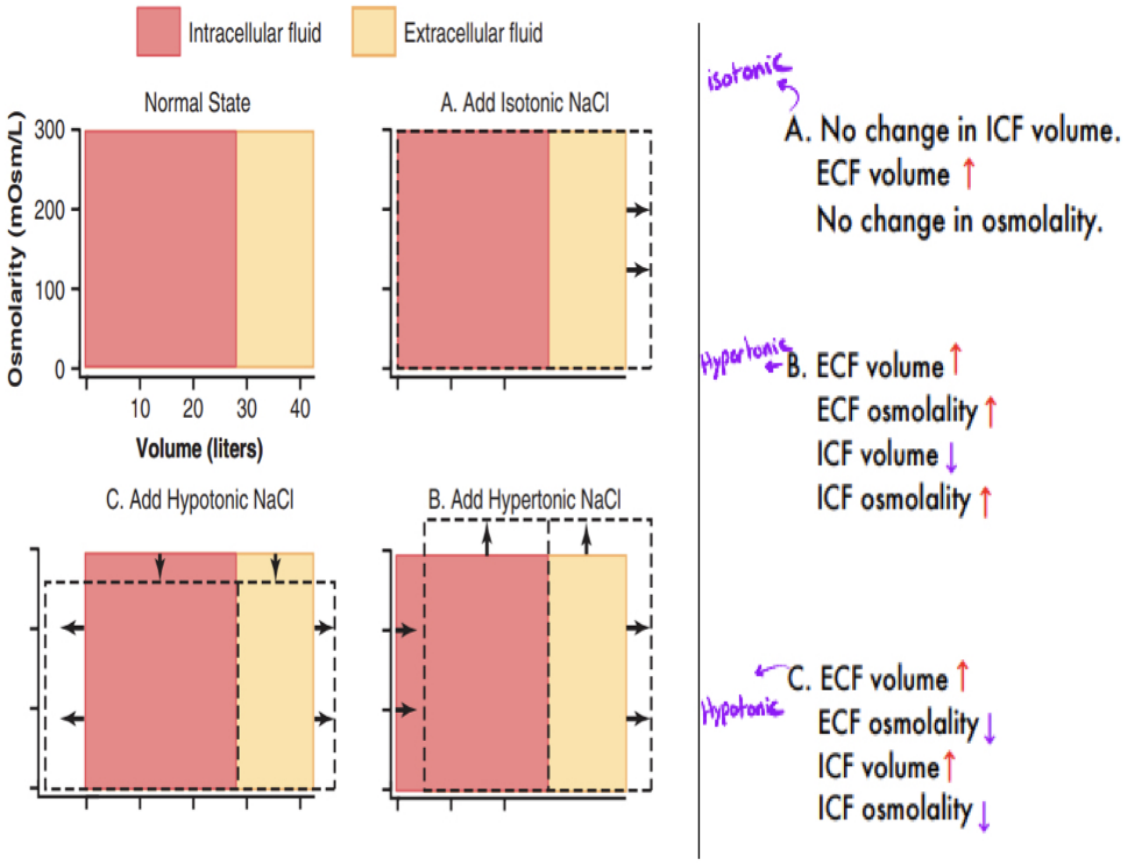
- **Hypernatremia with overhydration**

  High release of aldosterone (hyperaldosteronism) causes more Na+ retention and thus osmolality increases and volume increases.

Table 25-4 Abnormalities of Body Fluid Volume Regulation: Hyponatremia and Hypernatremia

Abnormality	Cause	Plasma Na^+ Concentration	Extracellular Fluid Volume	Intracellular Fluid Volume
Hyponatremia—dehydration	Adrenal insufficiency; overuse of diuretics	↓	↓	↑
Hyponatremia—overhydration	Excess ADH (SIADH); bronchogenic tumors	↓	↑	↑
Hypernatremia—dehydration	Diabetes insipidus; excessive sweating	↑	↓	↓
Hypernatremia—overhydration	Cushing's disease; primary aldosteronism	↑	↑	↓

ADH, antidiuretic hormone; SIADH, syndrome of inappropriate ADH.



A- If isotonic saline is added to the extracellular fluid compartment, the osmolarity of the extracellular fluid does not change; therefore, no osmosis occurs through the cell membranes. The only effect is an increase in extracellular fluid volume.

B- If a hypertonic solution is added to the extracellular fluid, the extracellular osmolarity increases and causes osmosis of water out of the cells into the extracellular compartment fluid diffuses from the cells into the extracellular space to achieve osmotic equilibrium. The net effect is an increase in extracellular volume (greater than the volume of fluid added), a decrease in intracellular volume, and a rise in osmolarity in both compartments.

C- If a hypotonic solution is added to the extracellular fluid, the osmolarity of the extracellular fluid decreases and some of the extracellular water diffuses into the cells until the intracellular and extracellular compartments have the same osmolarity.
-from the book: The sodium and chloride largely remain in the extracellular fluid because the cell membrane behaves as though it were virtually impermeable to the sodium chloride.

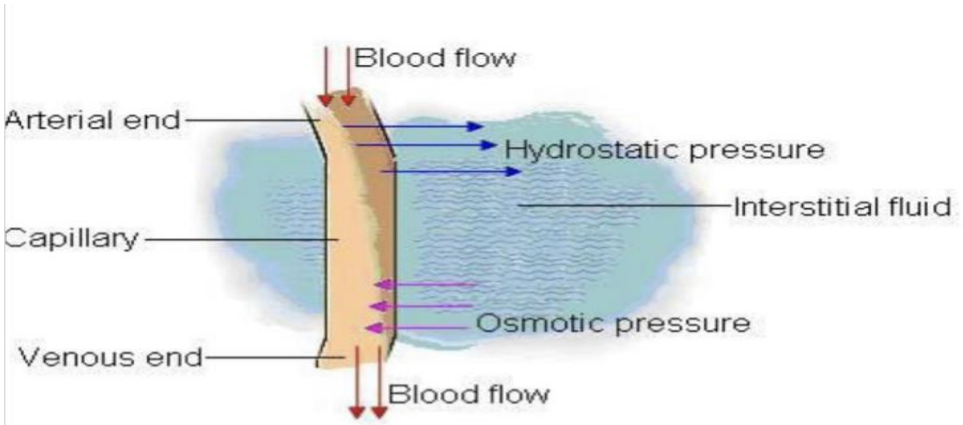
Oedema(Edema):

Quick info:

-oedema is localized retention of fluids at the interstitial compartment(which is a branch of the Extacellular fluid).

- it usually happens in the lower limb

Explain:



-we have filtration of fluids at the arterial end because of the hydrostatic pressure which cause the fluids to get out of the capillary to the interstitial fluids.
-we have reabsorption of these fluids at the venous end caused by the osmotic pressure.

-usually the amount of water filtrated is equal to the amount absorbed.

-if we have more filtration(higher hydrostatic pressure at the arterial end) And less reabsorption this will cause accumulation of the fluids at the interstitial compartment.

-the determinant for oncotic pressure at the level of capillaries is the presence of proteins such as albumin and this pressure is important to get reabsorption of water so if there is a decrease of protein content in the plasma this will result in decreasing the absorption so the net loss of water will be higher than the gain or absorption so this will cause edema.

- One of the most important causes of decreased plasma protein concentration is loss of proteins in the urine in certain kidney diseases, a condition referred to as nephrotic syndrome.

Causes of edema:

Increasing capillary filtration:

A.increased capillary hydrostatic pressure: - kidney causes more retention of water and salts(renal failure) - excess of mineralocorticoids (aldosterone).

B.high venous pressure:in normal conditions it's very low, and it caused by : heart failure,decrease of venous return(obstruction , decrease venous pump activity)

notes from the book the heart fails to pump blood normally from the veins into

the arteries, which raises venous pressure and capillary pressure, causing

increased capillary filtration. In addition, the arterial pressure tends to fall,

causing decreased excretion of salt and water by the kidneys, which causes still

more edema.

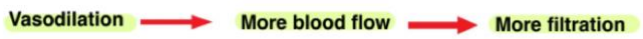
Also, blood flow to the kidneys is reduced in persons with heart failure, and this

reduced blood flow stimulates secretion of renin, causing increased formation of

angiotensin II and increased secretion of aldosterone, both of which cause

additional salt and water retention by the kidneys.

C. Decreased arterior resistance(more plasma and nutrients are able to be filtrated because of low resistance)



Vasodilation can be caused by 1- excessive body heat
2- insufficiency of SNS
3- vasodilators

By

-Osmotic pressure is also called colloid pressure

-Onotic pressure: caused by high amount of protein in plasma and low amount in interstitial fluid

Decreased onotic pressure:

Caused by two factors:

A.Increased loss of proteins:

-from kidney in nephrotic syndrome(خلل في عملية الارتشاح) (proteins are lost in urine causing protein foam in urine).

-from skin in burns and severe wounds.

notes from the book:

1-Failure to produce normal amounts of proteins or leakage of proteins from

the plasma causes the plasma colloid osmotic pressure to fall. This leads to

increased capillary filtration throughout the body and extracellular edema.

B.Decreased production of proteins:

Caused by:

-liver diseases(mostly the production of albumin)

-Decreased intake of proteins in malnutrition(سوء تغذية).

Note: patients who suffer from kidney and liver problems develop oedema.

Increase capillary permeability:

During immune reactions by release of histamine as a reaction of:

-Toxins

-Infections

-Vitamin C deficiency

- Ischemia(نقص التروية)

-Burns

Decreased lymph drainage:

Caused by:

-Cancer

-Infections

-Surgery

-Absence or abnormality of lymphatic vessels

Note:Lymph drainage can get proteins back from interstitial fluid to general circulation.

from the book:

When lymphatic function is greatly impaired as a result of blockage or loss of the

lymph vessels, edema can become especially severe because plasma proteins

that leak into the interstitium have no other way to be removed. The rise in

protein concentration raises the colloid osmotic pressure of the interstitial fluid, which draws even more fluid out of the capillaries.

Safety factors for preventing oedema haven't been discussed in this lecture(except of the first factor) , but I will upload mini sheet for the three factors when doctor upload this part online on teams. If you are in hurry, you can check 021 sheet in this link:

https://doctor2021.jumedicine.com/wp-content/uploads/sites/13/2022/04/Physiology-sheet-16-edited2_220509_173141.pdf

تم بحمد الله تعالى.