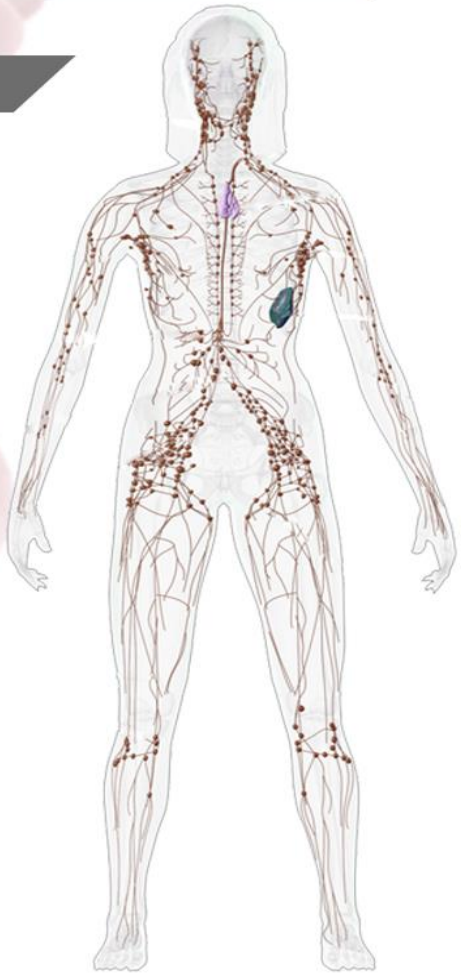
Sheet 11

Hematology and Lymphatic system

Subject | Physiology



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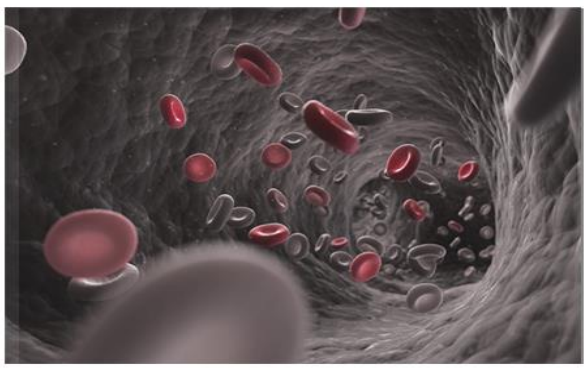


Body fluids

Major body fluid Compartments

-In a 70-Kg person, body fluid constitutes about 42 liters.

-Body fluids occupy two main Compartments:

1) The Intracellular Compartment holds most of the total body Fluids (28 liters out of 42).

2) The Extracellular Compartment that is further divided into:

Interstitial: 11 liters.

Plasma: 3 liters.

COMPOSITION OF EXTRACELLULAR AND INTRACELLULAR FLUID COMPARTMENTS
(values in meq/l unless otherwise indicated)

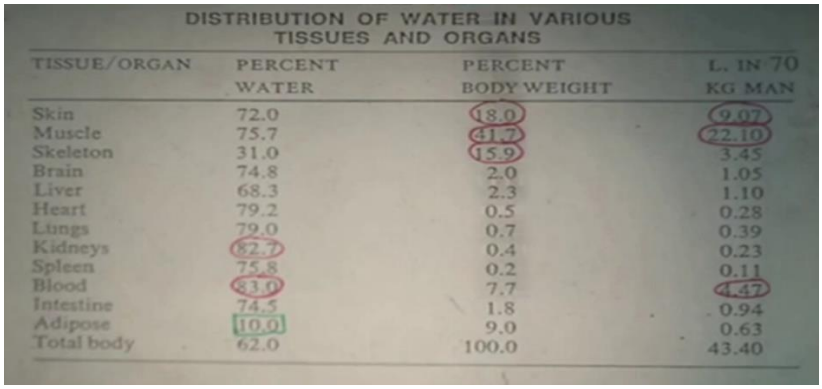
CONSTITUENTS AND PROPERTIES	EXTRACELLULAR FLUID		INTRACELLULAR FLUID
	PLASMA	INTERSTITIAL FLUID	
Sodium	142	145	10
Potassium	4	4	160
Calcium	5	5	2
Magnesium	2	2	26
Chloride	101	114	3
Sulfate	1	1	20
Bicarbonate	27	31	10
Phosphate	2	2	100
Organic acids	6	7	—
Proteins	16	1	65
Glucose (av)	90 mg%	90 mg%	0–20 mg%
Lipids (av)	0.5 g%	—	—
pH	7.4	7.4	6.7

Composition of extracellular and intracellular compartments:

1-The concentration of each substance in the plasma is like its concentration in the interstitial fluid**. EXCEPT** proteins which provide colloidal osmotic pressure (ranges between 25-28 mmHg). There is a significant difference between the concentration of proteins in plasma and the concentration of proteins in the interstitial fluid.

2-The concentration of sodium outside the cell is much higher than intracellularly. Whereas the concentration of potassium intracellularly is much higher than outside the cells. (note: The Na+/K+ pump has a key role in maintaining this state, if this pump does not function the human being will die).

3-The concentrations of potassium, sulfate, phosphate, and proteins are much higher inside the cells compared to their extracellular concentrations. On the other hand, the concentrations of sodium and chloride are much higher extracellularly compared to their intracellular concentrations.



DISTRIBUTION OF WATER IN VARIOUS TISSUES AND ORGANS

TISSUE/ORGAN	PERCENT WATER	PERCENT BODY WEIGHT	L. IN 70 KG MAN
Skin	72.0	18.0	9.07
Muscle	75.7	41.7	22.10
Skeleton	31.0	15.9	3.45
Brain	74.8	2.0	1.05
Liver	68.3	2.3	1.10
Heart	79.2	0.5	0.28
Lungs	79.0	0.7	0.39
Kidneys	82.7	0.4	0.23
Spleen	75.8	0.2	0.11
Blood	83.0	7.7	4.47
Intestine	74.5	1.8	0.94
Adipose	10.0	9.0	0.63
Total body	62.0	100.0	43.40

Distribution of water in various tissues and organs

1) blood has the highest amount followed by the kidneys.

2) Adipose tissue contains the lowest amount of water.

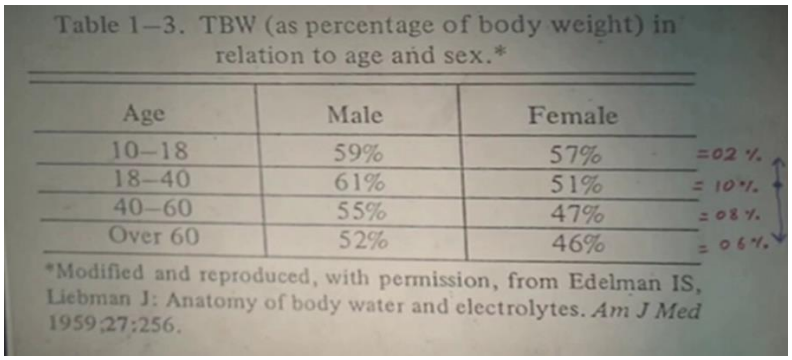


Table 1–3. TBW (as percentage of body weight) in relation to age and sex.*

Age	Male	Female	
10–18	59%	57%	=02 %.
18–40	61%	51%	= 10%.
40–60	55%	47%	= 08 %.
Over 60	52%	46%	= 06%.

*Modified and reproduced, with permission, from Edelman IS, Liebman J: Anatomy of body water and electrolytes. *Am J Med* 1959;27:256.

Total body water (TBW) in relation to age and sex:

It's important to see the different in water percentage between males and females.

• Before the age of 18(puberty), there's almost no difference in TBW (as a percentage of body weight) between males and females.

• Between the age of 18-40, there's a significant difference between males and females because of the effect of sex hormones. Females have a higher proportion of body fat; as a result, total body water is about 50% of their body weight, whereas about 60% of the body weight of an adult male is water.

• After the age of 40, the difference between males and females starts to decline gradually. (Note that the 10 % difference declines to 8% then to 6%).

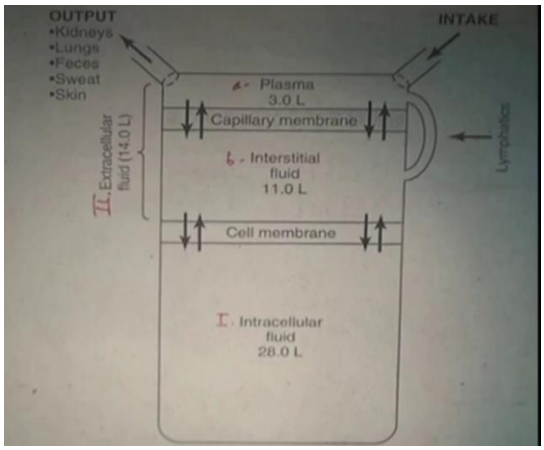
Osmolality of plasma

-The osmolality of plasma is around 290 mOsmol/kg.

-The principle ions (Na+, K+, Cl-, ..., etc.) contribute to 280 mOsmol/kg (about 96% of the osmolality of plasma). main ions are Na and Cl.

-Glucose, amino acids, and other small non-ionic substances contribute to approximately10 mOsmol/kg.

-Proteins contribute only around 0.5% to the total osmolality of plasma.



Water balance in the body:

-Fluid intake:

➢ Fluid ingested as liquid: 1.0 L

➢ Fluid from ingested food: 1.2 L

➢ Fluid from metabolism: 0.4 L

Total fluid intake = 2.6 L

-Fluid output:

➢ Through urine: 1.5 L (the value of fluid output through urine is changeable depending on the amount of the ingested fluid).

➢ through expiration: 0.5 L

➢ through sweat glands: 0.45 L (it's highly variable, depending on physical activity and environmental temperature)

➢ through feces: 0.15 L (can increase in people with severe diarrhea)

Total fluid output = 2.6 L

Note: from the value "fluid from ingested food" (1.2 L), we can tell that the numbers refer to populations of the Middle East and Asia because in European populations, very little amount of fluid comes from food.

Defense of body fluid volume:

There are defense mechanisms against abnormalities in body fluids (excess or reduced fluid volume).

A. In the case of increased body fluid volume (increased sodium intake and increased water retention):

Fluid intake = Fluid output = 2.6 L

-A hormone called **"Atrial Natriuretic Peptide (ANP)"** is released from the atria of the heart. This hormone increases sodium excretion.

-Reflex, ADH release from the posterior pituitary is inhibited consequently sodium

and water excretion is stimulated.

-The increased Na+ and water excretion restores normal body fluid volume.

B. In the case of reduced body fluid volume (decreased sodium intake and increased water release).

-Renin will be released from the kidneys. It will convert angiotensinogen into **angiotensin I** that will be further converted into angiotensin II by a converting enzyme in the lungs.

-Angiotensin II is responsible for:

1. Thirst so that the individual will drink more water.

2. Constriction of blood vessels.

3. Stimulation of the release of ADH.

4. Stimulation of the release of aldosterone from the adrenal cortex this will lead to increased reabsorption of Na+ and water.

-The decreased excretion of Na+ and water restores normal body fluid volume.

Dehydration:

-If the body mechanisms fail to operate properly, loss of fluid, electrolytes (ions), or both may occur. This is called dehydration.

-Three conditions (types) may arise depending on the relative losses of fluid and electrolytes:

1) Isotonic dehydration

Equal loss of fluid and electrolyte There is a proportionate loss of fluid and electrolyte so that the total volume of ECF changes, but its osmotic pressure remains within normal limits.

2) Hypertonic dehydration

Excessive fluid loss as compared to electrolytes

More fluid than electrolytes is lost. As a result, the ECF becomes more concentrated. Water thus tends to be drawn from cells.

3) Hypotonic dehydration

Excessive electrolyte loss as compared to fluids

More solute than fluid is lost, therefore, the ECF becomes diluted. Water thus tends to enter cells.

● causes of dehydration:

1) failure of water absorption from the GI.

2)Excessive loss from sweating, diarrhea, vomiting or excessive diuretics.

3)diabetic patients are usually dehydrated due to excessive urination

Hydration (water intoxication)

● **Causes of hydration:**

1)Excessive water intake

2)Decreased loss of water

3)Increased reabsorption of water from the kidney because of ADH administration.

Note: excessive water is evenly distributed between extracellular and intracellular, this increased water volume causes the dilution of the substances within the extracellular and intracellular.

● **Symptoms or consequences of water intoxication include:**

1)Disorientation, convulsions, and coma.

2)Gastrointestinal dysfunction, muscular weakness, and abnormal cardiac rhythms.

Note: if alcohol is unavailable, alcohol addicts tend to drink too much water (approximately 10L) because the result (disorientation) would be as if they got drunk due to alcohol intake.

Now how does substances go in and out of capillaries and vessels in the arterial and venous ends?

- In the arterial end the blood pressure is 32 and the colloidal osmotic pressure is 28 so filtration happens (movement of substances out of the vessels to the tissues).

- At the Venous end the blood pressure decreases to 16 and colloidal pressure doesn't change so osmosis occurs (the substance return from the interstitial spaces to the vessels by osmosis).

After osmosis little of plasma and proteins remain in the tissue these remaining go into lymphatics (the lymphatic system clears the interstitial space).

Note: lymph fluid that enters the lymphatic vessels drains venous blood via thoracic and right lymphatic duct.

Now we know that the plasma clots so lymph also clots since lymph is also plasma (so it contains clotting factors) but this clotting depends on the protein content of the plasma that differ by location (highest in the liver) so the tissue with the highest concentration of proteins may be susceptible to lymphatic clotting.

lymphocytes in circulation comes from lymphatic tissue and vessels so in the thoracic duct there is an appreciable number of lymphocytes.

components of the lymphatic system:

Lymphatic organs, Lymphatic vessels, Lymph nodes and Lymphatic ducts.

Typical Lymphatic Pathway:

Lymphatic system drains the interstitial spaces cleaning them then The substances cleared moves as lymph in lymphatic capillaries that merge with other capillaries to form afferent lymph vessels then it goes to lymph nodes where the lymph is filtered then moves through efferent lymphatic vessels to meet up with multiple other vessels to from the lymphatic trunk that merge with other trunks and joins the collecting duct then subclavian vein to enter the blood.

lymphatic related organs such as:

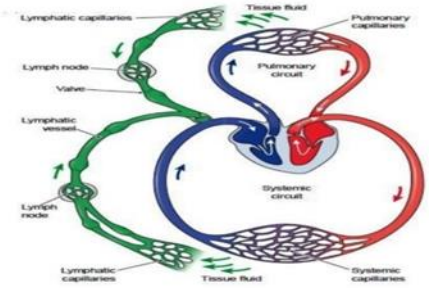
Spleen, tonsils and thymus.

Tissues that lack lymphatic vessels such as:

CNS, cornea of the eye, bone marrow, epidermis, portion of the spleen and avascular tissues.

Flow of lymph:

Lymph, like venous blood, is under relatively low pressure and may not flow readily through the lymphatic vessels without the aid of outside forces.



These forces include:

1-Contraction of skeletal muscles.

2-Pressure changes due to the action of breathing muscles.

3-Contraction of smooth muscles in the wall of larger lymphatic vessel.

The most important functions of the lymphatic system:

1-Return of excess filtered fluid, normally capillary infiltration exceeds reabsorption by about 3 liters per day (20L filtered, 17L reabsorbed).

2-Defense against disease, the lymph percolates through lymph nodes located on rout within the lymphatic system. Bacteria from interstitial fluid are destroyed by phagocytic cells in lymph nodes.

3-Transport of absorbed fat from the digestive tract.

4-Return of filtered protein, most capillaries permit leakage of some plasma proteins during filtration, these proteins cannot readily be reabsorbed back into the blood capillaries, but they can easily gain access to the lymphatic capillaries.

Edema

Edema is a condition caused by accumulation of fluid (as well as proteins) in the interstitial compartment.

• Probable causes of edema

1. High capillary pressure

Higher than normal amount of fluid is filtered.

Not the whole filtered blood will return to the capillary.

2. Low blood protein (low protein pressure)

The low protein pressure causes less than normal amounts of fluid to return by osmosis from the interstitial spaces.

3. Lymphatic blockage

Some parasites can block lymphatics and thus prevent fluid from returning to the circulation.

4. Increased capillary porosity

(Increase in the diameter of capillary pores) Same consequences as in the first cause.