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, pressure changes due to the action of breathing muscles, and ② contraction of smooth muscles in the walls of larger lymphatic vessels.

Following are the most important functions of the lymphatic system:

- *Return of Excess Filtered Fluid.* Normally, capillary filtration exceeds reabsorption by about 3 liters per day (20 liters filtered, 17 liters reabsorbed) (Fig. 8–17c). Yet the entire blood volume is only 5 liters, and only 2.75 liters of that is plasma. (Blood cells make up the remainder of the blood volume.) With an average cardiac output, 7,200 liters of blood pass through the capillaries daily under resting conditions (more when cardiac output increases). Even though only a small fraction of the filtered fluid is not reabsorbed by the blood capillaries, the cumulative effect of this process being repeated with every heartbeat results in the equivalent of more than the entire plasma volume being left behind in the interstitial fluid each day. Obviously, this fluid must be returned to the circulating plasma, and this task is accomplished by the lymph vessels. The average rate of flow through the lymph vessels is 3 liters per day, compared with 7,200 liters per day through the circulatory system.
- *Defense Against Disease.* The lymph percolates through lymph nodes located en route within the lymphatic system. Passage of this fluid through the lymph nodes is an important aspect of the body's defense mechanism against disease. For example, bacteria picked up from the interstitial fluid are destroyed by special phagocytic cells located within the lymph nodes.
- *Transport of Absorbed Fat.* The lymphatic system is important in the absorption of fat from the digestive tract. The end products of the digestion of dietary fats are packaged by cells lining the digestive tract into fatty particles that are too large to gain access to the blood capillaries but that can easily enter the terminal lymphatic vessels.
- *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. If the proteins were allowed to accumulate in the interstitial fluid rather than being returned to the circulation via the lymphatics, the interstitial-fluid-colloid osmotic pressure (an outward pressure) would progressively increase while the blood-colloid osmotic pressure (an inward pressure) would progressively fall. As a result, filtration forces would gradually increase and reabsorption forces would gradually decrease, resulting in progressive accumulation of fluid in the interstitial spaces at the expense of loss of plasma volume.

IMPORTANCE OF LYMPH FLOW

It has been estimated from studies in dogs with radioactively labeled plasma proteins that in one day 50 per cent or more of the total plasma protein is lost from the capillaries and returned to the blood stream by the lymphatic circulation. Furthermore, the amount of fluid filtered from the capillaries is greater than the amount reabsorbed. Inadequate lymph drainage can lead to an excessive accumulation of fluid in the interstitial space, a condition called edema. Some lymphedemas (edemas resulting from deficient lymph drainage) can cause gross disfiguring. An example is *elephantiasis*, a specific lymphedema resulting from blockage of lymph vessels. In a form of elephantiasis common in the tropics, the blockage follows invasion by a parasitic roundworm (filaria).

Edema

Edema is a condition caused by accumulation of fluid primarily in the interstitial compartment. Some factors involved in the production of edema are presented below.

TABLE 14-4 Causes of Edema

Factor altered	*Possible causes*
1. Increased capillary blood (hydrostatic) pressure	Arteriolar dilation Heart failure Prolonged standing
2. Decreased plasma osmotic pressure	Protein undernutrition Failure of plasma protein synthesis (liver disease) Excessive loss of plasma proteins in urine (kidney disease)
3. Increased capillary permeability	Inflammation Allergies Burns
4. Increased tissue osmotic pressure	Release of protein by damaged cells
5. Obstruction of lymphatic vessels	Injury Parasitism of lymphatic system (filariasis)

Edema may result from several main causes:

1. **Increased blood hydrostatic pressure in capillaries** due to an increase in venous pressure. This may result from poor blood flow back to the heart due to cardiac failure or blood clots.
2. **Decreased concentration of plasma proteins**, which lowers blood colloid osmotic pressure. Protein loss may result from burns, malnutrition, liver disease, and kidney disease.
3. **Increased permeability of capillaries**, which raises interstitial fluid osmotic pressure by allowing greater amounts of plasma proteins to leave the blood and enter tissue fluid. This may be caused by chemical, bacterial, thermal, or mechanical agents.
4. **Increased extracellular fluid volume** as a result of fluid retention. When a person has difficulty excreting fluids, for whatever reason, but continues to drink normal amounts of water, extracellular fluid in the body increases. Some of the fluid enters blood and increases blood hydrostatic pressure.
5. **Blockage of lymphatic vessels** as often occurs after a radical mastectomy (breast removal, usually because of cancer) or infection by filariasis roundworms. In a radical mastectomy, nearby lymph nodes that appear cancerous are removed with the breast tissue. Edema occurs in the arm on the same side because lymph drainage is blocked. The larvae of the tropical filariasis parasite invade and block lymphatic channels, causing the grossly disfiguring type of edema known as elephantiasis. ■

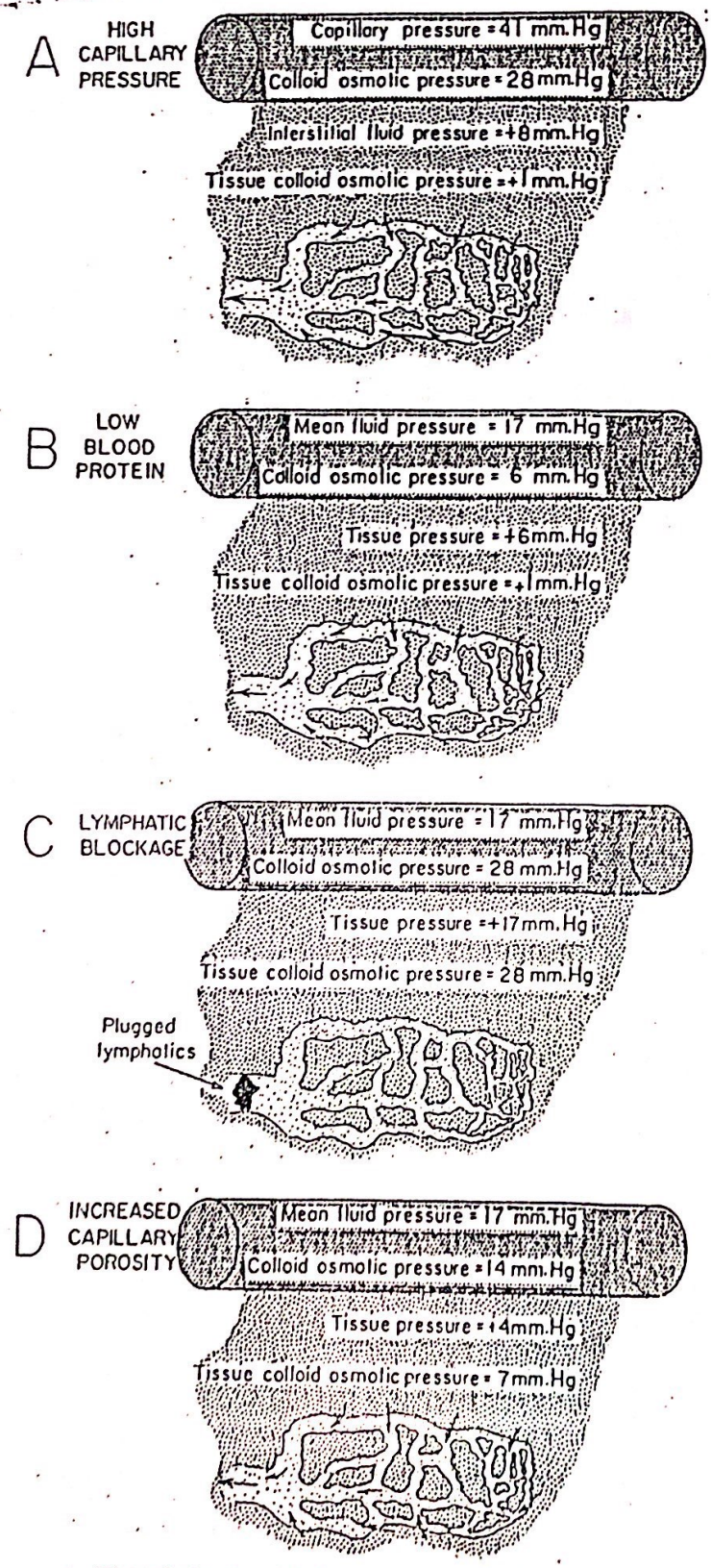


Figure 31–8. Various causes of edema.

DISTRIBUTION OF WATER IN VARIOUS TISSUES AND ORGANS

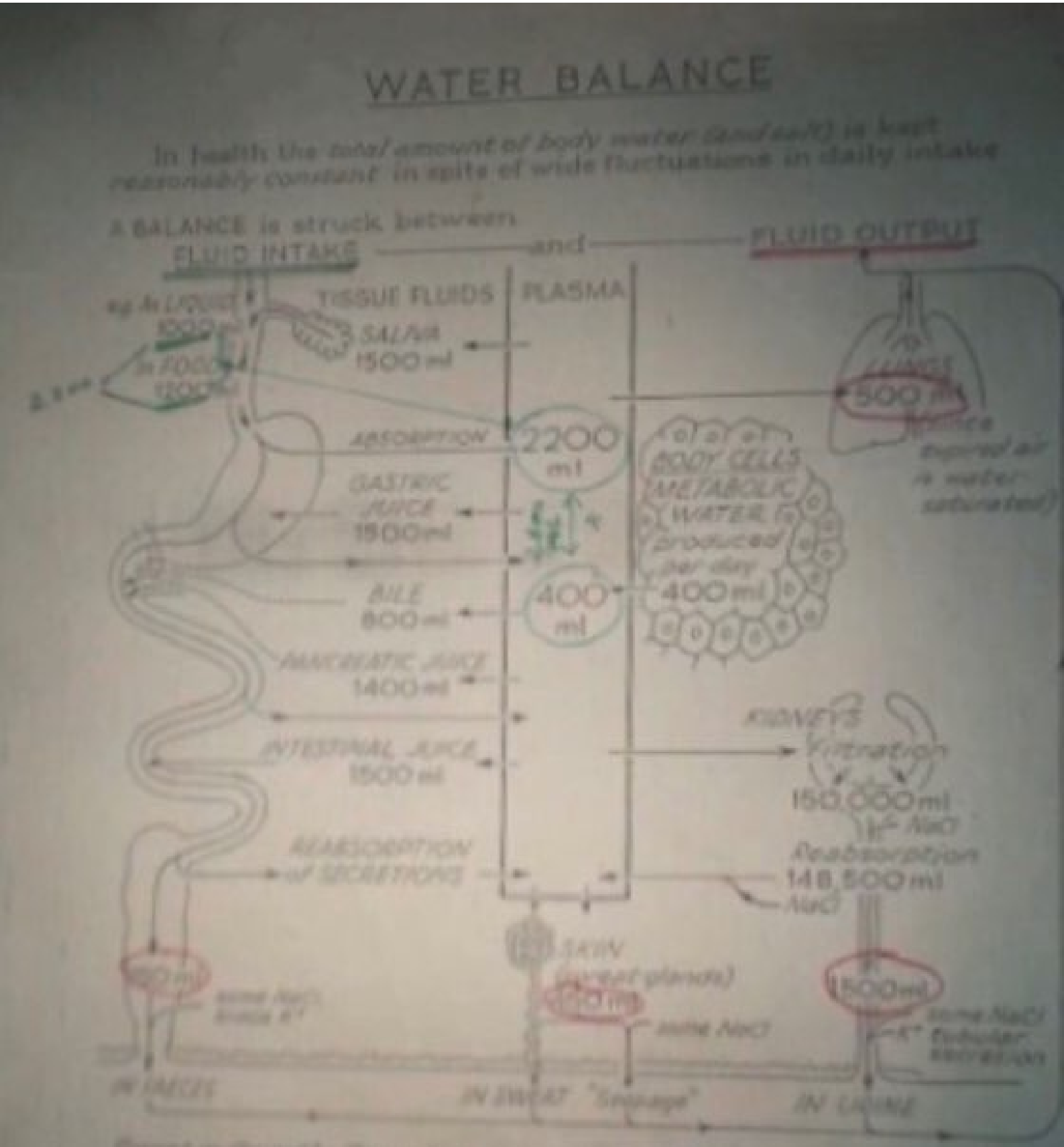
TISSUE/ORGAN	PERCENT WATER	PERCENT BODY WEIGHT	L. IN 70 KG MAN
Skin	72.0	18.0	9.07
Muscle	75.7	41.7	22.10
Skeleton	31.0	15.9	3.45
Brain	74.8	2.0	1.05
Liver	68.3	2.3	1.10
Heart	79.2	0.5	0.28
Lungs	79.0	0.7	0.39
Kidneys	82.7	0.4	0.23
Spleen	75.8	0.2	0.11
Blood	83.0	7.7	4.47
Intestine	74.5	1.8	0.94
Adipose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

WATER BALANCE

In health the *total amount of body water (and salt)* is kept *reasonably constant* in spite of wide fluctuations in daily intake

A BALANCE is struck between

FLUID INTAKE — and — FLUID OUTPUT



Except in Growth, Convalescence or Pregnancy, when new tissue is being formed, an INCREASE or DECREASE on INTAKE needs then appropriate INCREASE or DECREASE in OUTPUT to maintain the BALANCE

DEFENCE OF BODY FLUID VOLUME

The volume of the extracellular fluid (ECF) is determined mainly by the amount of osmotically active solute it contains. Na^+ is the most important active solute in the body, hence mechanisms that control Na^+ balance will also control ECF volume.

Clinical dehydration may be a consequence of :

1. Failure of absorption from the alimentary tract (as in pyloric stenosis or high intestinal obstruction).
2. Excessive loss from copious sweating, prolonged vomiting, diarrhea and excessive diuresis.
3. Drainage from wounds or burns.

HYDRATION; "WATER INTOXICATION"

HYDRATION is a term referring to the results of excessive water intake, decreased loss of water, or increased reabsorption of water from the kidney because of ADH administration. In such a case, the excess water is evenly distributed in both the ECF and ICF compartments, causing an increased water volume, with dilution of solutes in both areas. Excessive water intake may produce the syndrome of water intoxication in which cellular function is disturbed by the dilution of cellular electrolytes. Disorientation, convulsions, and coma may result, as well as gastrointestinal dysfunction, muscular weakness, and abnormal cardiac rhythms.