Edema

A variety of pathological conditions induces abnormalities in fluid balance, which are either an overload of fluid called *Edema* or a decrease in effective fluid referred to as *Dehydration*.

Edema refers to the disturbance of water balance in which there is an excess fluid in the body tissues. In most instances, edema occurs mainly in the extracellular fluid compartment, but it can involve intracellular fluid as well.

Types of Edema

1- Intracellular Edema

Three conditions are especially prone to cause intracellular swelling:

(1) Hyponatremia

(2) Depression of the metabolic systems of the tissues

(3) Lack of adequate nutrition to the cells.

When blood flow to a tissue is decreased, the delivery of oxygen and nutrients is reduced. If the blood flow becomes too low to maintain normal tissue metabolism, the cell membrane ionic pumps become depressed.

When the pumps become depressed, Na^+ that normally leak into the interior of the cell can no longer be pumped out of the cells and the excess intracellular Na^+ cause osmosis of water into the cells.

Sometimes this process can increase intracellular volume of a tissue area to 2 to 3 times normal. When such an increase in intracellular volume occurs, it is usually a prelude to death of the tissue.

Note: Intracellular edema can also occur in inflamed tissues. Inflammation usually increases cell membrane permeability, allowing Na^+ and other ions to diffuse into the interior of the cell, with subsequent osmosis of water into the cells.

2- Extracellular Edema

Extracellular fluid edema occurs when excess fluid accumulates in the extracellular spaces. ***There are two general causes of extracellular edema:***

(1) Abnormal leakage of fluid from the plasma to the interstitial spaces across the capillaries, causing interstitial fluid accumulation because of excessive capillary fluid filtration.

(2) Failure of the lymph vessels to return fluid and protein from the interstitium back into the circulation, often called **lymphedema**.

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.

Blockage of lymph flow can be especially severe with infections of the lymph nodes, such as infection by filaria nematodes (*Wuchereria bancrofti*), which are microscopic, threadlike worms. The adult worms live in the human lymph system and are spread from person to person by mosquitoes. People with filarial infections can have severe lymphedema and elephantiasis.

Lymphedema can also occur in persons who have certain types of cancer or after surgery in which lymph vessels are removed or obstructed. For example, large numbers of lymph vessels are removed during radical mastectomy, impairing removal of fluid from the breast and arm areas and causing edema and swelling of the tissue spaces. A few lymph vessels eventually regrow after this type of surgery, and thus the ***interstitial edema*** is usually temporary.

Edema demonstrates in the soft tissues as swelling of the limbs and face with a subsequent increase in size and tightness of the skin. ***Peripheral edema*** is reducible by increasing the pressure in the interstitial space and is measured by pressing a finger into the tissue which will create a formed dimple in the edematous skin temporarily.

Pulmonary edema may occur, where excess fluid swells into interstitial tissues of the lung, which is associated with cardiac failure and renal failure. Classically, cardiac failure causes pulmonary edema through decreased pumping efficiency and capacity of the left atria and left ventricle. Renal failure causes edema through a failure to remove fluids and osmotic components from the body.

Causes of extracellular edema

A large number of conditions can cause fluid accumulation in the interstitial spaces by abnormal leaking of fluid from the capillaries or by preventing the lymphatics from returning fluid from the interstitium back to the circulation. The following is a partial list of conditions that can cause extracellular edema by these two types of abnormalities:

1) ***Increase in capillary hydrostatic pressure (at arterial or venous side).***
   A. Excessive kidney preservation of salt and water; as in acute or chronic kidney failure.
   B. High venous pressure and venous constriction; as in heart failure.
   C. Decreased arteriolar resistance; as in excessive body heat and vasodilator drugs.

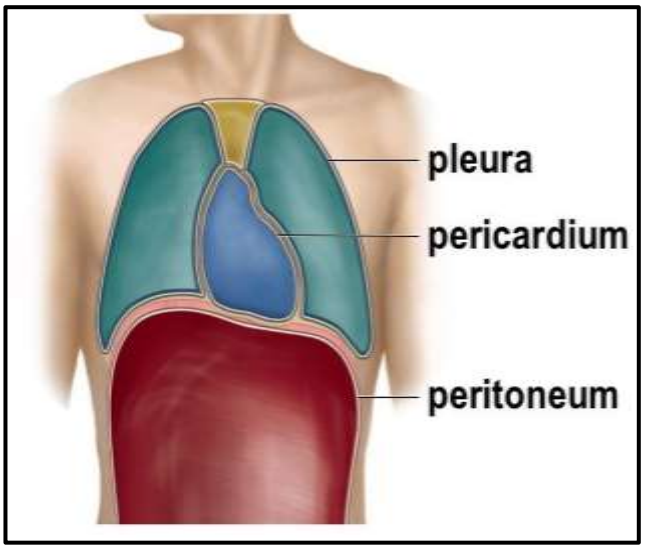
2) ***Increased capillary permeability***
   A. Immune reactions that cause release of histamine and other immune products.
   B. Toxins
   C. Bacterial infections
   D. Vitamin deficiency, especially vitamin C
   E. Prolonged ischemia
   F. Burns

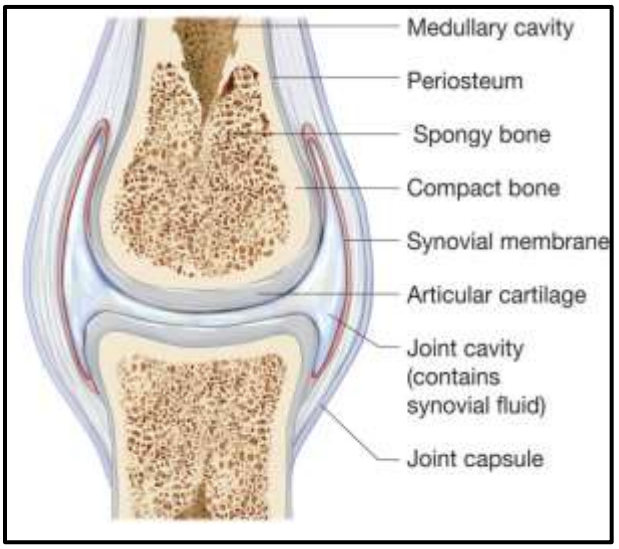
3) ***Decreased plasma proteins***
   A. Loss of proteins in urine (nephrotic syndrome).
   B. Loss of protein from denuded skin areas in burns and wounds.
   C. Failure to produce proteins; like in liver disease.

4) ***Blockage of lymph return***
   A. Cancer
   B. Infections (e.g., filaria nematodes)
   C. Surgery
   D. Congenital absence or abnormality of lymphatic vessels.

Fluid in the "Potential Spaces" of the body

Some examples of "potential spaces" are the thoracic cavity [include pleural cavity and pericardial cavity], peritoneal cavity, and synovial cavities. Virtually all these potential spaces have surfaces that almost touch each other, with only a thin layer of fluid in between, and the surfaces slide over each other.





The abdominal cavity is especially prone to collect body fluid; the other potential spaces, such as the pleural cavity, pericardial cavity, and joint spaces, can become seriously swollen when generalized edema is present.

Injury or local infection in any one of the cavities often blocks the lymph drainage, causing isolated swelling in the cavity.

Measurement of body fluid volume

Volume of different compartments of the body fluid is measured by ***indicator dilution method*** or by ***dye dilution method***. The volume of a fluid compartment in the body can be measured by placing an indicator substance in the compartment, allowing it to disperse evenly throughout the compartment's fluid, and then analyzing the extent to which the substance becomes diluted.

- **Measurement of Extracellular Fluid Volume:** The volume of extracellular fluid can be estimated using any of several substances that disperse in the plasma and interstitial fluid but do not readily permeate the cell membrane. They include radioactive sodium, radioactive chloride, radioactive iothalamate, thiosulfate ion, and inulin. When any one of these substances is injected into the blood, it usually disperses almost completely throughout the extracellular fluid within 30 to 60 minutes.

- **Measurement of Total Body Water:** Radioactive water (tritium, $3H_2O$) or heavy water (deuterium, $2H_2O$) can be used to measure total body water. These forms of water mix with the total body water within a few hours after being injected into the blood, and the dilution principle can be used to calculate total body water

  Calculation of Intracellular Volume: The intracellular volume cannot be measured directly. However, it can be calculated as

  Intracellular volume = Total body water - Extracellular volume

- **Measurement of Plasma Volume:** To measure plasma volume, a substance must be used that does not readily penetrate capillary membranes but remains in the vascular system after injection.

  Calculation of Interstitial Fluid Volume: Interstitial fluid volume cannot be measured directly, but it can be calculated as

  Interstitial fluid volume = Extracellular fluid volume - Plasma volume

Dehydration

Dehydration defined as significant decrease in total body water content due to pathologic fluid losses, reduced fluid intake, or a combination of both so that the body begins to lose its ability to function normally. It is a condition that can occur when the loss of body fluids, mostly water, exceeds the amount that is taken in. More water is moving out of individual cells and then out of the body than the amount of water that is taken in.

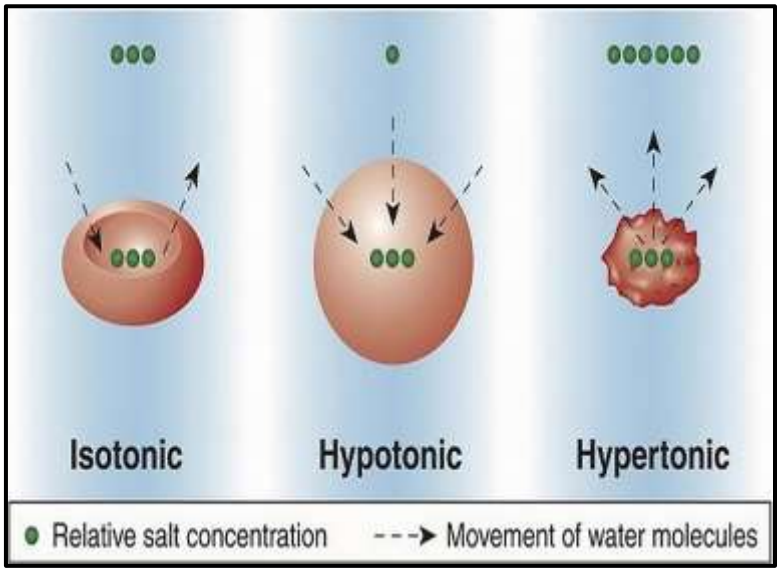
Clinicians tend to connect dehydration with the depletion of intravascular fluid.

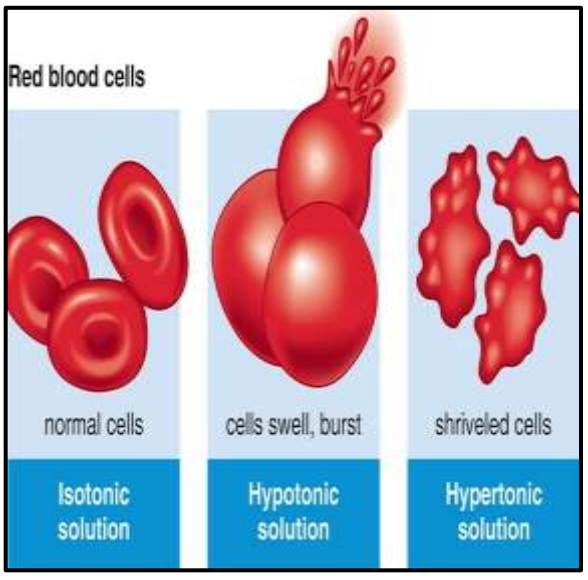
Depletion or reduction of intravascular fluid can take three forms depending on the proportion of water and sodium lost:

1- ***Hypertonic dehydration*** is depletion in total body water due to pathologic fluid losses, reduced water intake, or a combination of both. This leads to ***hypernatremia*** in the extracellular fluid compartment, which then draws water from the intracellular fluids. Since the water loss is shared by all body fluid compartments and leads to relatively little reduction in extracellular fluids, the individual's circulation is not compromised unless the loss is very great. This is also known as ***intracellular or hypernatremic dehydration***.

2- ***Hypotonic dehydration*** of extracellular, which is a fluid depletion where more sodium than water is lost (***hyponatremia)***, and extracellular fluid become depleted.

3- ***Isotonic or (isonatremic) dehydration***, which is a balanced depletion of both water and sodium, also leads to a loss of extracellular fluid. This is also known as ***isotonic fluid volume depletion.***





Classification of Dehydration

Basically dehydration is of three types:

1. Mild dehydration when fluid loss is about 5% of total body fluids.
2. Moderate dehydration when fluid loss is about 10%.
3. Severe dehydration when fluid loss is about 15%.

Causes of Dehydration

1- ***Severe Diarrhea*** - the most common cause of dehydration and related deaths. The large intestine absorbs water from food matter, and diarrhea prevents this from happening. The body excretes too much water, leading to dehydration.

2- ***Vomiting*** - leads to a loss of fluids and makes it difficult to replace water by drinking it.

3- ***Excess Sweating*** - the body's cooling mechanism releases a significant amount of water. Hot and humid weather and vital physical activity can further increase fluid loss from sweating. Similarly, a fever can cause an increase in sweating and may dehydrate the patient, especially if there is also diarrhea and vomiting.

4- ***Diabetes*** - high blood sugar levels cause increased urination and fluid loss. Tips for handling summer heat for people with diabetes.

5- ***Frequent urination*** - usually caused by uncontrolled diabetes, but also can be due to alcohol and medications such as diuretics, antihistamines, blood pressure medications, and antipsychotics.

6- ***Burns*** - blood vessels can become damaged, causing fluid to leak into the surrounding tissues.

Signs and Symptoms

Mild to moderate dehydration

1. Excess thirst is the first sign of dehydration
2. Dryness of the mouth, headaches, tiredness and a lack of energy
3. Decrease in sweating
4. Decrease in urine formation, which is darker yellow in color than usual
5. Pale and dry skin
6. Decreased tears
7. Loose of 3-5 % & 5-9% of body weight in mild and moderate dehydration respectively.

Severe dehydration

Beside the previous signs become more intensity and getting worse:

1. Decrease in blood volume and cardiac output.
2. Cardiac shock.
3. Deep breath with rapid breath and pulse.
4. Minimum urination
5. Become confused or disorientated; also feel irritable.
6. Loose of 10% of body weight.

Very severe dehydration

1. Damage of organs like brain, liver and kidneys
2. Mental depression and confusion
3. Renal failure
4. Coma.