Hemodynamic Disorders, Thrombosis, and Shock

The health of cells and tissues depends on the circulation of blood, which delivers oxygen and nutrients and removes wastes generated by cellular metabolism. As blood normally passes through capillary beds, proteins in the plasma are retained within the vasculature and there is little movement of water and electrolytes into the tissues .

This balance is often disturbed by pathologic conditions that alter endothelial function, increase vascular pressure, or decrease plasma protein content, all of which promote **edema** .

EDEMA (oedema)

60 % of normal body weight is **water**, 2/3 of which is intracellular & 1/3 is in extracellular in a form of interstitial fluid; only 5% of total body's water is in blood plasma

Edema Is abnormal and excessive accumulation of interstitial fluid within tissues .

Extravascular fluid can also collect in body cavities referred to as **effusions** .

Examples of effusions include :-

- (Collection of extravascular fluid in Pleural cavity) ***hydrothorax***.

- *(*Collection of extravascular fluid in *Pericardial cavity)* ***hydropericardium*** .

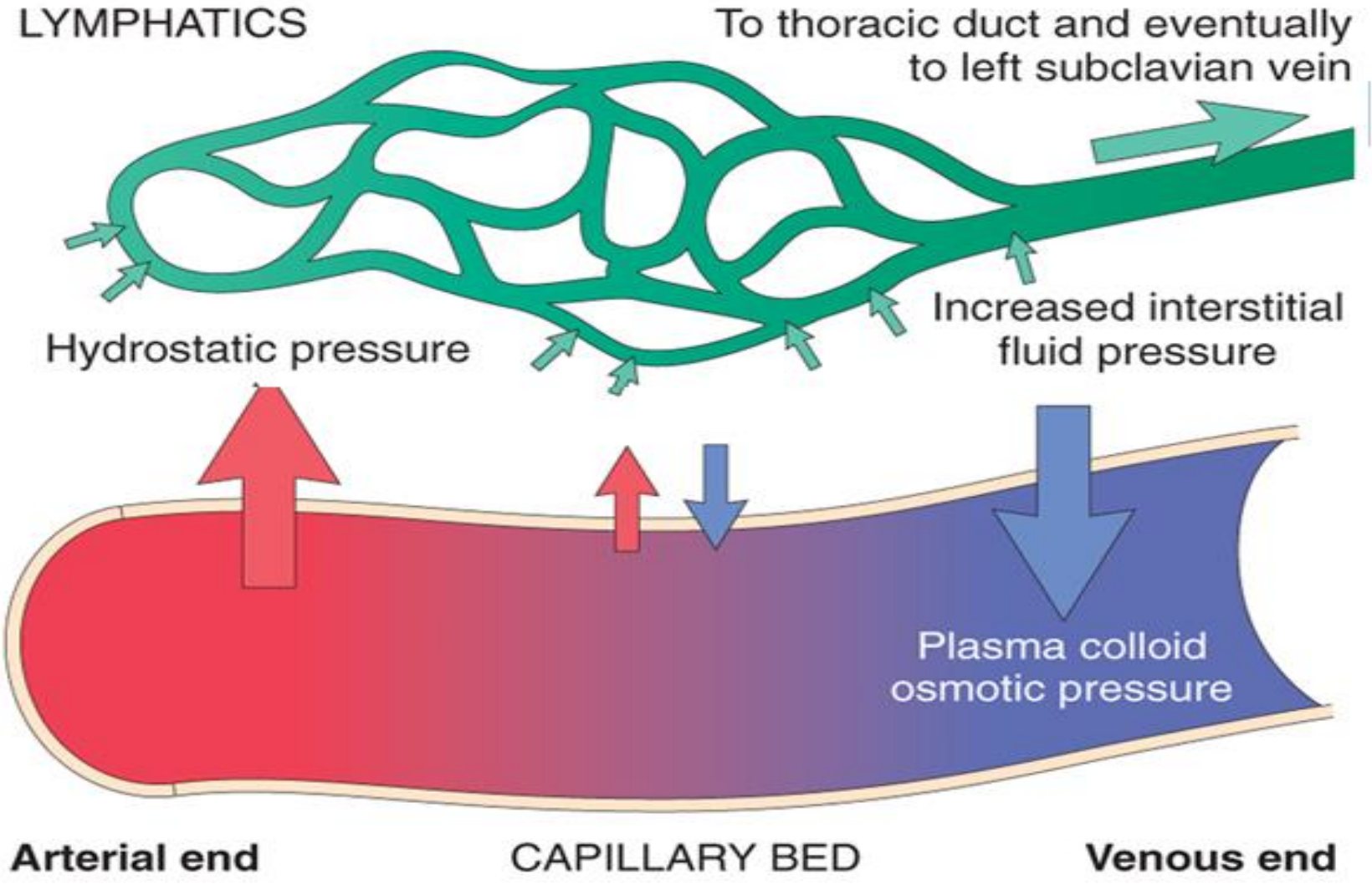
- (Collection of extravascular fluid in peritoneal cavity) ***hydroperitoneum*** (which is also is called ***Ascites***).

Anasarca is a severe and generalized edema marked by profound swelling of subcutaneous tissues and accumulation of fluid in body cavities.

Mechanism of Non Inflammatory Edema

The movement of fluid between vascular and interstitial spaces is controlled mainly by the opposing forces : **the vascular hydrostatic pressure and the plasma colloid osmotic pressure** produced by plasma proteins . Normally, the outflow of fluid produced by hydrostatic pressure at the arteriolar end of the microcirculation is balanced by inflow of fluid produced by osmotic pressure at the venular end ; hence there is only a small residual amount of fluid into the interstitial space, which is drained by lymphatic vessels. Either increased hydrostatic pressure or diminished colloid osmotic pressure causes increased movement of water into the interstitium .

lymphatic obstruction (e.g., due to scarring or tumor) can also impair fluid drainage and cause edema .



Factors affecting fluid transit across capillary walls. Capillary balanced so there hydrostatic and osmotic forces are normally littlie net movement in to the interstitium .

Types of edema

1- inflammatory edema is a protein- rich *exudate* with a specific gravity that is usually greater than 1.020, occur due to increased vascular permeability .

2-non inflammatory edema is typically a protein-poor *transudate ;* it has a specific gravity less than 1.012occur due to other reasons other than inflammation .

Causes of non inflammatory edema

1- Increased Hydrostatic Pressure.

2- Reduced Plasma Osmotic Pressure (Hypoproteinemia).

3- Lymphatic Obstruction.

4- Sodium and Water Retention .

1- Increased Hydrostatic Pressure.

Increases in hydrostatic pressure are caused by disorders that impair venous return .

Localized **:-** increases in intravascular pressure for example:-

A- deep venous thrombosis in lower extremity can cause edema restricted to the distal portion of the affected leg.

B- portal hypertension caused by liver cirrhosis .this produce edema in the peritoneal cavity .

C- pressure of gravid uterus on the iliac veins produces edema of the lower limbs.

Generalized **:-** increases in venous pressure, with resultant systemic edema, occur most commonly in ***congestive heart failure*** *in which* reduced cardiac output.

Reduced cardiac output lead to systemic venous congestion and resultant increase in capillary hydrostatic pressure.

At the same time reduction in cardiac output lead to reduced renal perfusion (hypoperfusion) .

Renal hypoperfusion in turn triggers the renin – angiotensin -aldosterone axis, inducing sodium and water retention by the kidneys. In patients with normal heart function, increases cardiac filling and cardiac output, thereby improving renal perfusion. However, the failing heart often cannot increase its cardiac output in response to the compensatory increases in blood volume. Instead, a vicious circle of fluid retention, increased venous hydrostatic pressures, and worsening edema ensues. Unless cardiac output is restored or renal water retention is reduced the edema is continues .

2- Reduced Plasma Osmotic Pressure

Albumin accounts for almost half of the total plasma protein . Albumin is either lost from the circulation or synthesized

in inadequate amounts are common causes of **reduced**

plasma osmotic pressure.

1- lost of albumin from the circulation as In ***nephrotic syndrome*** in which glomerular capillary walls become leaky; leading to the loss of albumin in the urine and the development of generalized edema .

2- reduced albumin synthesis occurs in sever liver diseases (e.g., liver cirrhosis)

3- Protein malnutrition .

In each case, reduced plasma osmotic pressure leads to accumulation of fluid into the interstitial tissues resulting edema .

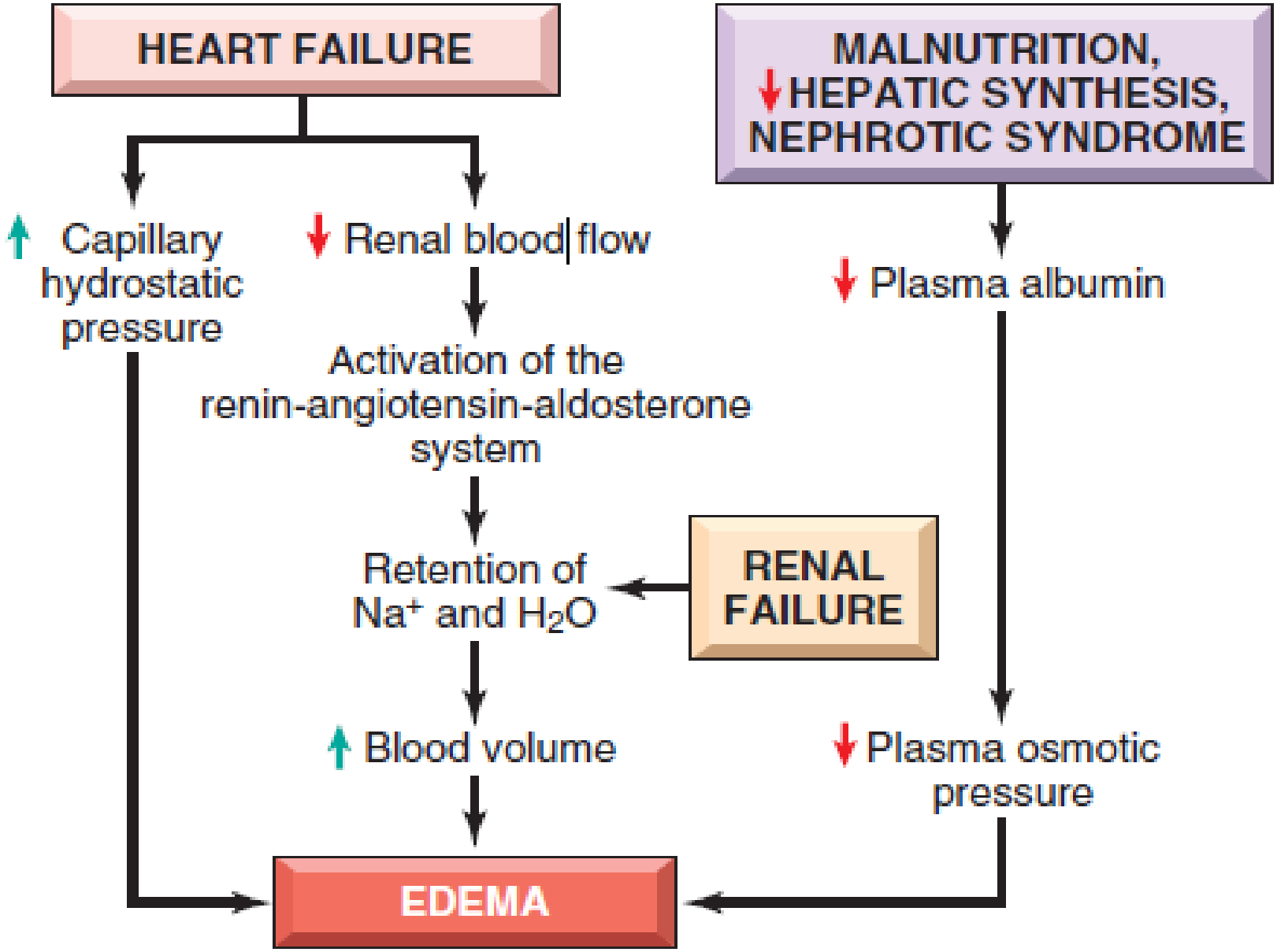


Figure 3–3 Pathways leading to systemic edema due to heart failure, renal failure, or reduced plasma osmotic pressure.

3- Lymphatic Obstruction

Obstruction of lymphatic drainage and consequent *lymphedema* is usually localized , result from **inflammatory** or **neoplastic** obstruction. For example, the parasitic infection ***filariasis*** can cause extensive inguinal lymphatic and lymph node fibrosis. The resultant edema of the external genitalia and lower limbs (so-called **elephantiasis**) .

Cancer of the breast can be treated by resection of the associated axillary lymph nodes; the resultant loss of lymphatic drainage can cause upper extremity edema .

Obstruction of superficial lymphatics by breast cancer may cause edema of the overlying skin; the characteristic finely pitted appearance of the skin of the affected breast is called **peau d'orange (orange peel) .**

4- Sodium and Water Retention

Excessive retention of salt (with the obligate accompanying water) can lead to edema by increased hydrostatic pressure (due to expansion of the intravascular volume) and reduced vascular osmotic pressure . Excessive salt and water retention are seen in a wide variety of diseases that compromise renal function, including **poststreptococcal glomerulonephritis** and **acute renal failure** .

Morphology of edema

Macroscopically edema is easily recognized as swelling .

Microscopically shows clearing and separation of the extracellular matrix elements .

Although any organ or tissue in the body may be involved, edema is most commonly encountered in subcutaneous tissues, lungs, and brain .

Subcutaneous edema can be diffuse but usually accumulates preferentially in parts of the body positioned below the heart where hydrostatic pressures are high . Thus, edema typically is most pronounced in the legs with standing and the sacrum with recumbency , a relationship termed **dependent edema** . Finger pressure over edematous subcutaneous tissue displaces the interstitial fluid, leaving a finger-shaped depression; this appearance is called **pitting edema**.

Edema due to **renal dysfunction** or **nephrotic syndrome** is often manifests first in loose connective tissues (e.g., the eyelids, causing **periorbital edema**) **.**

Pulmonary edema the lungs often are two to three times their normal weight, and sectioning reveals frothy, blood-tinged fluid consisting of a mixture of air, edema fluid, and extravasated red cells .

Brain edema can be **localized** (e.g., due to abscess or tumor) or **generalized** depending on the nature and extent of the pathologic process or injury. With generalized edema, the sulci are narrowed while the gyri are swollen and flattened against the skull.

Clinical Features of edema

The effects of edema may range from merely annoying to rapidly fatal

1- Subcutaneous edema is important to recognize

because it signals potential for underlying cardiac or renal disease.

2- Pulmonary edema can cause death by interfering with normal ventilatory function; besides impeding oxygen diffusion , alveolar edema fluid also creates a favorable environment for infections.

3-Brain edema is serious and can be rapidly fatal.

HYPEREMIA AND CONGESTION

hyperemia* and *congestion both *refer to an increase in blood volume within a tissue* but they have different mechanisms.

Hyperemia is an *active process* resulting from arteriolar dilation and increased blood inflow (e.g., at sites of inflammation or in skeletal muscle during exercise). The hyperemic tissue is redder than normal because of engorgement with oxygenated blood.

Congestion is a *passive process* resulting from impaired outflow of venous blood from a tissue. It may occur **systemically**, as in cardiac failure, or it may be **local**, resulting from an isolated venous obstruction. The congested tissue has a blue-red color *(cyanosis),* which results from accumulation of deoxygenated hemoglobin in the affected tissues .

Congestion of capillary beds is closely related to the development of edema , so that congestion and edema commonly occur together.

MORPHOLOGY

Macroscopically Cut surfaces of hyperemic or congested tissues feel wet and ooze blood..

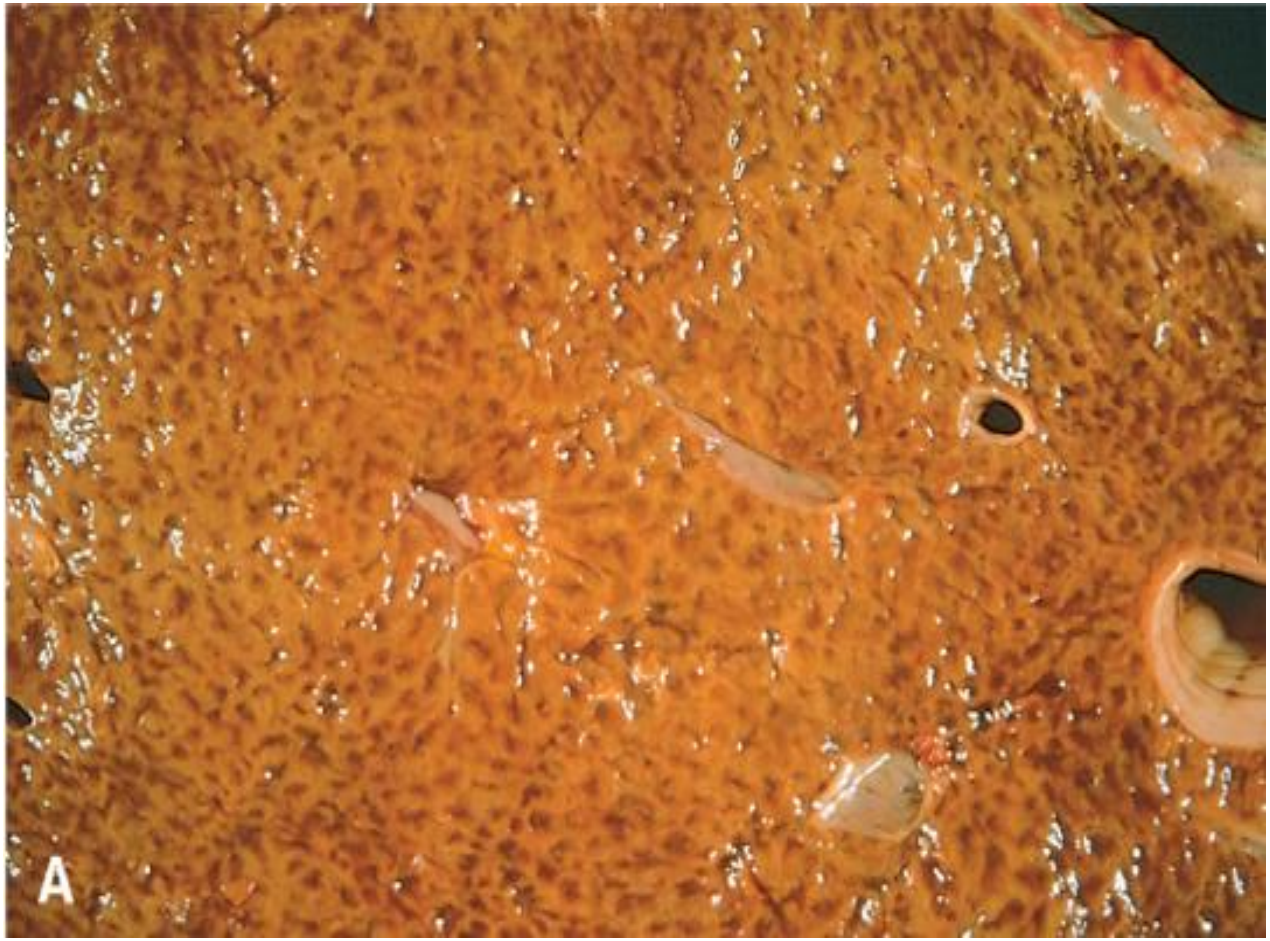
Microscopically,

Acute pulmonary congestion is characterized by alveolar capillaries engorged with blood and variable degrees of alveolar septal edema and intra-alveolar hemorrhage.

Chronic pulmonary congestion the septa become thickened and fibrotic, and the alveolar spaces may contain numerous hemosiderin-laden macrophages **("heart failure cells")**.

Acute hepatic congestion the central vein and sinusoids are distended with blood, and there may even be necrosis of central hepatocyte ; the periportal hepatocytes , better oxygenated because of their proximity to hepatic arterioles, undergo less severe hypoxia and may develop only fatty change.

Chronic hepatic congestion , the central regions of the hepatic lobules are grossly red-brown and slightly depressed (because of a loss of cells) and surrounded by zones of uncongested tan, sometimes fatty liver called **(nutmeg liver).** Microscopically, there is centrilobular necrosis of hepatocyte , hemorrhage, and hemosiderin-laden macrophages



Liver with chronic passive congestion and hemorrhagic necrosis. **A,** Central areas are red and slightly depressed compared with the surrounding tan viable parenchyma, forming a "nutmeg liver" (so called because it resembles the alternating of light and dark seen when a whole nutmeg is cut).

HEMORRHAGE

Hemorrhage is extravasation of blood from vessels into the extravascular space .

Causes

The risk of hemorrhage is increased in a wide variety of clinical disorders collectively called **hemorrhagic diatheses.**

1- trauma .

2- Chronic congestion will result in capillary rupture.

3- Coagulation disorder .

4- Atherosclerosis .

5- inflammatory or neoplastic erosion of the vessel wall .

Types of hemorrhage

Hemorrhage can be external or can be confined within a tissue.

1- Hematomas : which ranges in significance from trivial (e.g., a bruise) to fatal (e.g., retroperitoneal hematoma resulting from rupture of a dissecting aortic aneurysm)

2- *Petechiae* : minute hemorrhages (1- to 2-mm) into skin, mucous membranes, or serosal surfaces . causes include low platelet counts (*thrombocytopenia*), defective platelet function, and loss of vascular wall support, as in vitamin C deficiency.

3- *Purpura* : slightly larger hemorrhages (3- to 5-mm) can be associated with the same disorders that cause petechiae ; in addition, purpura can occur with trauma, vascular inflammation (*vasculitis*).

4-*Ecchymoses :* larger (1- to 2-cm) subcutaneous hematomas (colloquially called bruises) . Extravasated red cells are phagocytosed and degraded by macrophages; the characteristic color changes of a bruise are due to the enzymatic conversion of hemoglobin (red-blue color) to bilirubin (blue-green color) and eventually hemosiderin (golden-brown) .

5- Large accumulations of blood in the body cavities are called according to location :- *hemothorax (in pleura) , hemopericardium (in pericardium , hemoperitoneum(in peritonium),* or *hemarthrosis* (in joints).

Clinical significance of hemorrhage

depends on the volume of blood lost and the rate of bleeding .

1-Rapid removal of as much as 20% of the blood volume or slow losses of even larger amounts may have little effect in healthy adults .

2-Greater losses, however, can cause *hemorrhagic (hypovolemic) shock* .

3- The site of hemorrhage is also important; bleeding that would be trivial in the subcutaneous tissues may cause death if located in the brain.

4- Chronic or recurrent external blood loss (e.g., a peptic ulcer or menstrual bleeding) causes a net loss of iron, frequently culminating in an iron deficiency anemia.