

Haemodynamic Disorder

M. O. Al-Sohaibani, MBBS, FCAP, FRCPath

- **INTRODUCTION TO**

- **HAEMODYNAMIC DISORDERS**

- The metabolism of organs and cells depends on an intact circulation for the continuous delivery of oxygen, nutrients, hormones, electrolytes, and water for the removal of metabolic waste and carbon dioxide. Delivery and elimination at the cellular level are controlled by exchanges between the intravascular space, interstitial space, cellular space and lymphatic space.

- **HEMORRHAGE**

Diff : Escape of blood of blood vessels (artery or vein) rupture, due to trauma, atherosclerosis, inflammation or neoplastic erosion of the vessel wall, hypertension as cerebral or retinal. It can occur externally or internally.

Hemorrhage (bleeding) is a discharge of blood from the vascular compartment to the exterior of the body or into nonvascular body spaces. The most common and obvious cause is **trauma**. However, an artery may be ruptured in ways other than laceration. For instance, severe atherosclerosis may so weaken the wall of the abdominal aorta that it balloons to form an **aneurysm**, which then ruptures and bleeds into the retroperitoneal space. By the same manner, an aneurysm may complicate a congenitally weak cerebral artery (berry aneurysm) and lead to subarachnoid haemorrhage. Tuberculosis also erodes blood vessels and a similar vascular injury is caused by invasive tumours.

Hemorrhage also results from damage at the level of the capillaries. For instance the rupture of capillaries by blunt trauma is evidenced by the appearance of a bruise. Increased venous pressure also causes extravasation of blood from capillaries in the lung. Vitamin C deficiency is associated with capillary fragility and bleeding, owing to a defect in the supporting structures. A severe decrease in the number of platelets (thrombocytopenia) or a deficiency of a coagulation factor (e.g., factor VIII in hemophilia) is associated with spontaneous hemorrhages unrelated to any apparent trauma.

A person may exsanguinate into an internal cavity, as in the case of gastrointestinal hemorrhage from a peptic ulcer (arterial hemorrhage) or esophageal varices (venous hemorrhage). In such cases, large amount of fresh blood fill the entire gastrointestinal tract. Bleeding into a serous cavity can result in the accumulation of a large amount of blood, even to the point of exsanguination. A few definitions are in order:

- Significance of Hemorrhage
- Volume of blood loss
- Rate of blood loss.
- Hemorrhagic (hypovolemic) shock.
- Site of hemorrhage.

- **Hemothorax:** Hemorrhage into the pleural cavity.
- **Hemopericardium:** Hemorrhage into the pericardial space.
- **Hemoperitoneum:** Bleeding into the peritoneal cavity.
- **Hemarthrosis:** Bleeding into a joint space.

Hematoma: Hemorrhage into the soft tissues. Such collections of blood can be merely painful, as in a muscle bruise, or fatal, if located in the brain.

- **Purpura:** Diffuse superficial hemorrhage in the skin, up to 1 cm. in diameter.
- $\geq 3\text{mm}$ hemorrhages into skin, mucous membranes and or serosal surfaces.

- **Causes:-** Local increase in intravascular pressure
- pressure, low platelet counts (thrombocytopenia) and defective plt function.
- Trauma, local vascular inflammation (Vasculitis), and increased vascular fragility (e.g. in amyloidosis)

- **Ecchymosis:** A large superficial hemorrhage. Larger (≥ 1 to 2 cm) subcutaneous hematomas, and change colour over time due to local degradation of hemoglobin when phagocytosed by tissue macrophages. (red-blue colour \rightarrow blue-green colour \rightarrow golden brown).
- **Causes:-** Trauma and others.

Following a bruise or in association with a coagulation defect, an initially purple discoloration of the skin turns green and then yellow before resolving. This sequence reflects the progressive oxidation of bilirubin released from the hemoglobin of degraded erythrocytes. A good example of an ecchymosis is a black eye which may follow a blunt injury to the face.

- **Petechia:** are minute 1-2 mm haemorrhages into the skin, mucous membranes and serosal surfaces.
- A pinpoint hemorrhage, usually in the skin or conjunctivae. This lesion represents the rupture of a capillary or arteriole and occurs in conjunction with coagulopathies or vasculitis, the latter classically associated with infections of the heart valves (bacterial endocarditis).

Causes:- Local increase in intravascular pressure, low platelet counts (thrombocytopenia) and defective plt function.

- **HYPEREMIA**

- Hyperemia is defined as an excess amount of blood in an organ.
- Is an active process resulting from increased tissue blood flow.

- **ACTIVE HYPEREMIA**

- Active hyperemia is an augmented supply of blood to an organ, usually as a physiologic response to an increased functional demand, as in the case of the heart and skeletal muscle during exercise.
- The most striking active hyperemia occurs in association with inflammation. Vasoactive material released by inflammatory cells cause dilatation of blood vessels, in the skin this results in the classic “tumor, rubor, and calor” of inflammation. In pneumonia, the alveolar capillaries are engorged with erythrocytes as a hyperemic response to inflammation.

- **PASSIVE HYPEREMIA (Congestion)**
- Passive hyperemia or congestion refers to the engorgement of an organ with venous blood. Acute passive congestion is clinically a consequence of acute failure of the left ventricle. The resulting venous engorgement of the lung leads to the accumulation of a transudate in the alveoli, a condition termed pulmonary edema. A generalized increase in venous pressure, typically from chronic heart failure, results in slower blood flow and a consequent increase in the volume of blood in many organs, including the liver, spleen and kidneys.

Passive congestion may also be confined (limited) to a limb or an organ as a result of more localized obstruction to the venous drainage. Examples include deep venous thrombosis of the leg, with resulting edema of the lower extremity, and thrombosis of the hepatic veins (Budd-Chiari syndrome) with secondary chronic passive congestion of the liver.

LUNG:

Chronic failure of the left ventricle constitutes an impediment to the exit of blood from the lungs and leads to chronic passive congestion of that organ. As a result, the pressure in the alveolar capillaries is increased, and these vessels become engorged with blood.

- Acute left ventricular failure – Acute pulmonary congestion.
- Accumulation of transudate.
- Pulmonary edema.
- Chronic pulmonary congestion.
- Microhemorrhages, heart failure cells.
- Pulmonary edema.
- Pulmonary fibrosis.
- Pulmonary hypertension.

The increased pressure in the alveolar capillaries has four major consequences.

1. Microhemorrhages release erythrocytes into the alveolar spaces, where they are phagocytosed and degraded by alveolar macrophages. The released iron, in the form of hemosiderin, remains in the macrophages, which are then called “heart failure cells”.

2. The increased hydrostatic pressure forces fluid from the blood into the alveolar spaces, resulting in pulmonary edema, a dangerous condition that interferes with gas exchange in the lung.

3. The increased pressure, together with other poorly understood factors, stimulates fibrosis in the interstitial spaces of the lung. The presence of fibrosis and iron is viewed grossly as a firm, brown lung (“brown induration”).

4. The increased capillary pressure is transmitted to the pulmonary arterial system, a condition labelled pulmonary hypertension. This disorder leads to right-sided heart failure and consequent generalized venous congestion.

- **LIVER**: The liver, with the hepatic veins emptying into the vena cava immediately inferior to the heart, is particularly vulnerable to chronic passive congestion. The central veins of the hepatic lobule become dilated. The increased venous pressure is transferred to the sinusoids, where it leads to dilatation of the sinusoids with blood and pressure atrophy of the centrilobular hepatocytes.

Grossly, the cut surface of the chronically congested liver exhibits dark foci of centrilobular congestion surrounded by paler zones composed of unaffected peripheral portions of the lobules. The result is a curious reticulated appearance, resembling a cross section of a nutmeg (the seed of an East Indian tree which is grated and used as a spice), and is appropriately called “nutmeg liver”.

SPLEEN: Increased pressure in the liver, from cardiac failure or an intrahepatic obstruction to the flow of blood (e.g. cirrhosis), results in higher portal vein pressure, which is transmitted to the splenic vein pressure and leads to congestion of the spleen. The organ becomes enlarged and tense, and the cut section oozes dark blood. In long standing congestion diffuse fibrosis of the spleen is seen, together with iron-containing, fibrotic and calcified foci of old hemorrhage (Gamma-Gandy bodies). Fibrocongestive splenomegaly may result in an organ that weighs 250 to 750 g, compared with a normal weight of 150 g.