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Diploma in Pharmacy 1st Year Human Anatomy and Physiology Chapter 5 : Haemopoietic System	
Topics	Page No

Chapter 5

Haemopoietic System

Blood

- Blood is a connective tissue that plays a vital role to carry various life processes and protects the body against diseases
- Haematology is the branch of medical science concerned with the study of blood, blood-forming tissues, and blood disorders.
- The system of organs and tissues, including the bone marrow, spleen, thymus and lymph nodes, involved in the production of cellular blood components is known as haematopoietic system.

Composition of Blood

- Blood is a connective tissue, having a liquid matrix with cells and cell fragments.
- Around 8% of total body weight is blood (adult female 4-5 litres and adult male 5-6 litres).
- More than half of the total blood volume is plasma and less than half is formed elements:
  1) Blood Plasma, a clear extracellular fluid, and
  2) Formed elements, composed of blood cells and platelets. These are classified as follows:
  i) RBCs ii) WBCs il) Platelets

Blood Plasma

- Around 55% of blood (2.7-3.0 litres in an average human) constitutes blood plasma, i.e., blood's liquid medium (golden-yellow in colour).
- Blood plasma has 92% water, 8% blood plasma proteins, and other substances in trace amount

Functions of Blood Plasma Proteins

- Essential for Blood Clotting:
- Maintain Colloidal Osmotic Pressure of Blood and Regulate the Distribution of Fluid between Blood and Tissues:
- Maintain Viscosity and Blood Pressure:
- Concerned with Erythrocyte Sedimentation Rate (ESR):
- Act as a Protein Reserve:
- Helps CO_2 Carriage:
- Antibodies:
- Helps to Transport Certain Substances in Blood:

Red Blood Cells (Erythrocytes)

- RBCs are discotic-shaped cells constituting 99% of the blood and carrying haemoglobin molecules.

Function of RBCs

- Oxygen Transporter:
- Release of ATP and Vessel Dilation:
- Immunity:

White Blood Cells (Leukocytes)

- WBCs fight against external organisms. They are described according to their characteristics, morphology, and staining property.
- They are granulocytes and agranulocytes corresponding to the presence or absence of granules (lysosomes)

Types of Leukocytes

Granular Leukocytes or Granulocytes: The granulocyte refers to three types of WBCs.

1. Neutrophils,
2. Eosinophils,
3. Basophils

Functions of WBCs are:

→ Phagocytosis
→ Antibody Formation
→ Fibroblasts Formation
→ Trephones Synthesis
→ Heparin Secretion
→ Antihistamine Function

Platelets (Thrombocytes)

➲ They are very small , non nucleated dics of diameter 2-4 um, obtained from cytoplasm of megakaryocytes in red bone marrow . Its constituents promote blood clotting leading to haemostasis (Stop bleeding)

Functions of Platelets

- Vasoconstriction
- Platelet plug formation
- Coagulation (Blood Clotting)
- Fibrinolysis

Functions of Blood

Following are some major functions performed by the blood:

i. Transportation
ii. Thermoregulation
iii. Hydraulic Function
iv. Act as a Vehicle
v. Maintenance of Ion Balance
vi. Property of coagulation
vii. Respiratory Function
viii. Excretory Function

ix. Transport of Hormones and Enzymes
x. Regulation of Water Balance
xi. Regulation of Acid-Base Balance
xii. Regulation of Body Temperature (Homeostsis)
xiii. Storage Function
xiv. Defensive Function

Process of Haemopoeisis

→ Hematopoiesis is the production of all of the cellular components of blood and blood plasma. It occurs within the hematopoietic system, which includes organs and tissues such as the bone marrow, liver, and spleen. Simply, hematopoiesis is the process through which the body manufactures blood cells.

→ Around 250 billion (25×10^{10} new RBCs, 20 billion (20×10^{9}) new WBCs, and 25 billion (20×10^{9}) platelets are required for replacing the aged or dead cells each day.

→ Formation of blood cells (RBCs, WBCs, platelets) is termed as haemopoiesis or haematopoiesis and the tissues involved in this process are known as haematopoietic tissue.

Erythropoiesis

- Formation of red blood cells is known as erythropoiesis.

Leucopoiesis

- Formation of White Blood Cells is known as leucopoiesis

Thrombopoiesis

- Formation of Platelets is known as thrombopoiesis

Formation of Haemoglobin

Haemoglobin (Hb) is a respiratory pigment present in RBCs and giving them their red colour. It is conjugated protein having 4% heme (Fe^{+2} and porphyrin) and 96% globin protein. It is synthesised within the immature erythrocytes during erythropoiesis, in the red bone marrow.

Normal Level of Haemoglobin in Human Body

The age, sex, altitude, exercise, excitement and adrenaline level affects the Hb level in the blood.

- Normal haemoglobin level in males is 14- 17gm/100 ml,
- Normal haemoglobin level in females is 12- 15gm/100 ml), and
- Normal haemoglobin level in newly born babiesis 14.5-18.5.

Blood Clotting

- Blood coagulation (or blood clotting) is the process by which blood from its liquid state changes to a gel-like consistency.
- A host defence mechanism known as haemostasis is a complex process which blocks the bleeding from a damaged vessel.
- Platelet adherence and aggregation to macromolecules in the sub-endothelial tissues forms a primary haemostaticplug.
- Activating plasma coagulation factors by platelets lead to the generation of a fibrin clot that builds up the platelet aggregate.
- Shedding of platelet aggregate and fibrin clots occurs when the wound starts healing.

Factors of Blood Clotting

- Factor I - fibrinogen
- Factor II - prothrombin
- Factor III - tissue thromboplastin (tissue factor)
- Factor IV - ionized calcium (Ca++)
- Factor V - labile factor or proaccelerin
- Factor VI - unassigned
- Factor VII - stable factor or proconvertin
- Factor VIII - antihemophilic factor
- Factor IX - plasma thromboplastin component, Christmas factor
- Factor X - Stuart-Prower factor
- Factor XI - plasma thromboplastin antecedent
- Factor XII - Hageman factor
- Factor XIII - fibrin-stabilizing factor

Mechanism of Blood Clotting

The process of coagulation is a cascade of enzyme catalysed reactions wherein the activation of one factor leads to the activation of another factor and so on.

The three main steps of the blood coagulation cascade are as follows:

i. Formation of prothrombin activator
ii. Conversion of prothrombin to thrombin
iii. Conversion of fibrinogen into fibrin

1. Formation of prothrombin activator

→ The formation of a prothrombin activator is the first step in the blood coagulation cascade of secondary haemostasis. It is done by two pathways, viz. extrinsic pathway and intrinsic pathway.

Extrinsic Pathway

- It is also known as the tissue factor pathway. It is a shorter pathway. The tissue factors or tissue thromboplastins are released from the damaged vascular wall. The tissue factor activates the factor VII to VIIa. Then the factor VIIa activates the factor X to Xa in the presence of Ca2+.

Intrinsic Pathway

- It is the longer pathway of secondary haemostasis. It begins with the exposure of blood to the collagen from the underlying damaged endothelium. This activates the plasma factor XII to XIIa.
- XIIa is a serine protease, it activates the factor XI to XIa. The XIa then activates the factor IX to IXa in the presence of Ca2+ ions.
- The factor IXa in the presence of factor VIIIa, Ca2+ and phospholipids activate the factor X to Xa.

Common Pathway

- The factor Xa, factor V, phospholipids and calcium ions form the prothrombin activator. This is the start of the common pathway of both extrinsic and intrinsic pathways leading to coagulation.

2. Conversion of prothrombin to thrombin

→ Prothrombin or factor II is a plasma protein and is the inactive form of the enzyme thrombin. Vitamin K is required for the synthesis of prothrombin in the liver. The prothrombin activator formed above converts prothrombin to thrombin. Thrombin is a proteolytic enzyme. It also stimulates its own formation, i.e. the conversion of prothrombin to thrombin. It promotes the formation of a prothrombin activator by activating factors VIII, V and XIII.

3. Conversion of fibrinogen into fibrin

→ Fibrinogen or factor I is converted to fibrin by thrombin. Thrombin forms fibrin monomers that polymerise to form long fibrin threads. These are stabilised by the factor XIII or fibrin stabilising factor. The fibrin stabilising factor is activated by thrombin to form factor XIIIa. The activated fibrin stabilising factor (XIIIa) forms cross-linking between fibrin threads in the presence of Ca2+ and stabilises the fibrin meshwork. The fibrin mesh traps the formed elements to form a solid mass called a clot.

Blood Group

- A blood type or blood group is the classification of blood on the basis of the presence or absence of inherited antigens (proteins, carbohydrates, glycoprotein, or glycolipids) on the surface of RBCs.
- Understanding of blood is significant for the following practices :
- Blood grouping is essential for both donor and receiver for successful blood transfusion

- Blood grouping is important to resolve paternity disputes and medico legal cases
- It is significant in diagnosis of some blood grouping related diseases and conseguences.

Depending on the type of antigens present or absent on the membrane of RBCs, various blood grouping system are follow :

I. Classical ABO blood grouping system,
II. Rhesus (Rh) blood grouping system,
III. MNS blood grouping system, and
IV. P blood grouping system.

First two are major blood grouping systems and are more prevalent in the population and cause severe transfusion reaction, while the last two are minor blood grouping systems found in small proportion of the population and produce minute transfusion reactions.

ABO Blood Group

ABO blood group is based on A and B antigens on the RBCs surface. This system classifies blood on the basis of antigens located on the surface of RBCs and circulating antibodies in plasma. Combination of proteins and their antibodies form four types of blood:

Type A: It consists of protein A and antibodies for protein B.
Type B: It consists of protein B and antibodies for protein A.
Type AB: It consists of proteins A and B but no antibodies.
Type O: It does not consist of any proteins but have both A and B antibodies.

Thus, type AB blood group is universal receiver and can receive any blood type; whereas type O blood group is universal donor and can donate blood to anyone.

Rh Blood Group

It was first detected in Rhesus monkey. Sometimes Surface antigens of RBCs have the Rh factor. 97% Indian population have Rh positive (i.e. presence of Rh antigens) else have Rh negative blood group.

Importance of Blood Grouping

1) In blood transfusion;
2) Haemolytic disease of newborn;
3) Paternity dispute;
4) Medicolegal issues;
5) Susceptibility to various diseases (blood group O peptic ulcer blood group A -gastric ulcer);
6) Immunology, genetics, anthropology
7) To identify criminals.

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