Blood products and plasma substitutes –

Blood is a connective tissue which makes 7-9% part of total body weight of adult human. The total volume of blood is 4.5 to 5.5 liter in an adult. The functions of blood include – maintenance of pH (7.35 – 7.45), transportation of gases (O_2 and CO_2), Transportation of different metabolites, nutritious substances, hormones, drugs and nitrogenous waste products of body like urea, ammonia etc., regulation of immune defence and body temperature. Blood is a natural buffer that regulates acid- base balance in body.

Different blood products –The various types of products that are obtain from blood and useful in different blood related threats are known as blood products-

1. **Whole human blood** – Whole human blood is red coloured opaque concentrated solution which include total blood composition with extra anticoagulants in it. On standing state of 24 to 48 hours it's corpuscles are readily settled in bottom part and clear supernatant layer is seen.
   Collection – Always blood should be collected from healthy human with no infectious disease state under rigid aseptic environment. The blood is collected from median cubital vein in front of elbow in a sterile container. Blood is collected with adequate mixing of the anticoagulants in the container (plastic bag or glass bottle). Not more than 420 ml is collected in one attendance.
   Storage – After withdrawal of the blood from healthy human, it should be cooled immediately at 4℃ to 6℃ and regularly maintain this temperature throughout it's shelf life of 21 days.
   Anticoagulants- For prevention of fibrin clots anticoagulants are added in blood. The anticoagulants generally added are citrates, heparin and Disodium edentate. Acid citrate dextrose (ACD) is used as blood anticoagulant solution. The dextrose delays haemolysis of erythrocytes in vitro and prolongs their life after transfusion and citrate prevents clotting by binding with calcium ions as unionized calcium citrate. Heparin is expensive, it is used when large volumes of blood is transfused to one patient, where high amount of citrate is harmful, for example in cardiac surgery.
   Testing- At the time the blood is taken, two small additional amounts are collected one for testing of compatibility of blood and other one for testing of Rh grouping and blood groups.
   Use – The volume of blood can be reduced to dangerously low level by haemorrhage, burn, shock, diarrhea and vomiting. Whole human blood is transfused to replace total blood or part of blood either cellular or plasma and also useful in total restore of blood volume in acute haemorrhagic condition in stroke and trauma patient.

2. **Concentrated human red blood corpuscles** - It is prepared from whole human blood which is not more than 14 days old according pharmacopoeial regulations. The upper supernatant fluid is siphoned off and cellular layer of whole human blood after centrifugation is collected to prepare concentrated human red blood corpuscles.
   Storage – Storage temperature of concentrated human red blood corpuscles is 4℃ to 6℃ as it prepared from whole human blood. It should be used within 12 hours of preparation to avoid risk of bacterial contamination.

Use - Concentrated human red blood corpuscles are transfused to treat various types of anaemia.

3. **Plasma** – Plasma is also prepared from whole human blood that is collected as the supernatant layer after centrifugation (as mentioned in concentrated RBCs).
   Storage – Storage temperature for Plasma is also 4℃ to 6℃ but it should be used immediately after preparation due to its unstability in liquid state.
   Use – In haemorrhage and shock, plasma is used as replacing agent of blood volume as it has similar osmotic properties and nutritional values of whole human blood. Whole blood is ideal for this purpose but it is not readily available so plasma can be used as substitute of whole human blood in haemorrhagic or shock patients.

4. **Dried human plasma** - As whole human blood requires refrigerated storage and need to be used within three weeks, dried human plasma is prepared by plasma with the help of freeze drying after sterility testing. Dried plasma is usually prepared from time expired citrated blood. The supernatant fluid is separated and batches of 10 bottles are pooled, correct ratio of blood groups is chosen to neutralize the agglutinins. The pools are kept at 4 to 6 ℃. After sterility testing they are subjected to freeze drying. It is a light deep cream sterile powder which is reconstituted with the help of water for injection at room temperature. It can be given to patients of any blood group.
   Dried human serum is prepared in same way as dried plasma except that the blood is collected in dry bottles and allowed to clot, supernatant serum is separated after the clot formation.
   Storage - Dried human plasma should be stored at room temperature but temperature should not exceed 45℃. If properly stored dried plasma can be kept for five years. Dried plasma kept below 20℃ and protected from light, moisture and oxygen remain usable. It is reconstituted in water for injections, sodium chloride injections or 2.5 percent dextrose. After reconstitution it should be used immediately.
   Use – It is used as restoration agent of blood volume in hemorrhage, severe burns and shock condition. Reconstituted plasma is a satisfactory alternative to whole blood if there is no loss of red blood cells. Due to its long shelf life it can be kept in reserved stock.

5. **Plasma Protein Fraction** – The only official liquid blood product is human plasma protein fraction. About 60 percent of plasma protein is albumin and it plays major role in maintaining high osmotic pressure necessary to retain fluid in blood vessels. It is a fraction of plasma in which selected proportion of albumin and globulin proteins remains protein concentration 45gm/lit. Fractionation process involves the reduction in solubilities of proteins in plasma by use of organic solvents like ether and ethanol at low temperatures. It is an isotonic solution of neutral pH and additional microbial and stabilizing agent (sodium caprylate or acetyl tryptophan added to allow the preparation to be heated for several hours at a low temperature without denaturation of proteins).
   Storage - Plasma Protein Fraction should be stored at 2℃- 10℃ for 5 years.

Use –Plasma protein fraction used as source of protein and replacing agent in non- haemorrhagic shock. Human Albumin – It is obtained from pooled human plasma. Heat treated preparation of human albumin can be used in acute hypoproteinaemia, acute liver failure and dialysis.

Plasma Substitutes –

Due to limited supply of blood, limitation in the quantity of human blood products and risk of transmission of serum hepatitis lead to find the substitutes from non-human origin. Plasma substitutes or plasma expanders have relatively high molecular weight substances and capable to increase plasma volume by increasing osmotic pressure. These agents should be iso-osmotic with plasma and pharmacodynamically inert and free from toxicity. The uses of plasma substitutes are commonly as in hypovolemic shock, prevention of thrombosis and also useful as isotonic solution. The following agents are useful for substitute of plasma –

1. Gum saline- It is a synonym of sodium chloride and acacia injection. It was used in first world war, it is 6 % Acacia in 0.9 % NaCl solution.
2. Polyvinyl pyrrolidone-In Second World War Germans introduced this synthetic colloid for treatment of shock. It is a synthetic polymer of average molecular weight 40,000. It is used as 3.5% solution.
3. Dextran- It is the most satisfactory and common example of plasma substitutes with highest use. Dextran is highly branched polysaccharide that is obtained from fermentation of sucrose using a strain of leuconostoc mesenteroids. It means dextran is a product of bacterial origin from sucrose medium. In sugar industry it occurs as slime that clogs pipes and filters. The organism secretes an enzymethat converts sucrose to dextran. Production of dextran is by process of fermentation through cultures.This most commonly used plasma expander is available mainly in two forms – Dextran 40 and Dextran 70.
4. Dextran 40 – Dextran 40 is a polymer of glucose that have average molecular weight 40,000. In this polymer the monomeric units of glucose are linked together by 1,6-glycosidic linkage. Dextran 40 is a white, amorphous powder without taste and odour. Also it is freely soluble in water. It acts more rapidly than dextrose 70. It is given by intravenous infusion of 10% concentration of normal saline.
   Storage – Dextran 40 can be stored at room temperature for 5 years.
5. Dextran 70 – It is the most commonly used preparation of Dextran that expands plasma volume for nearly 24 hrs. Dextran 70 is a polymer of glucose that have average molecular weight 70,000.
6. Degraded gelatin polymer – It is a synthetic polymer of molecular weight 30,000 that is obtained from bone and hydrolysed under controlled conditions. It expands plasma volume upto 12 hrs.
7. Hydroxyethyl Starch – It is a complex mixture of amylopectin which has been treated with ethylene chlorohydrins. It improves hemodynamic status for 24 hours.
8. Absorbable haemostats- These materials are used to control and arrest bleeding when it cannot be controlled by more conventional means. They are gradually absorbed by the tissues and can be left in body during surgery. The examples include human fibrin foam, gelatin sponge, oxidized cellulose and calcium alginate. Human fibrin foam is sponge like mass of human fibrin.

It is prepared by whipping the fibrinogen froth and adding thrombin to it. It is poured into trays and freeze dried and sterilized. A piece of fibrin foam is dipped into thrombin solution and applied to bleeding area. Absorbable gelatin sponge is prepared by adding small percentage of formaldehyde to warm solution of gelatin and whisked into a foam and freeze dried. The porous product is cut into pieces and sterilized by dry heat. It is marketed as papery white pieces that are extremely light and spongy. It absorbs many times its own weight of blood. Oxidised cellulose is an absorbable haemostatic material where cellulose is converted into polyanhydro glucuronic acid by oxidation with nitrogen dioxide. On contact with blood it turns dark and swell to gelatinous coagulum. Calcium alginate is derived from alginic acid, a colloidal substance obtained from seaweeds Laminaria digitata. Alginic acid is a polyuronide built up from d-manuronic acid units. Its carboxyl groups react with metal ions to form alginate. Calcium alginate dressing have marked haemostatic effect that is due to mechanical pressure.It is used to arrest external bleeding from surgical incisions, tooth sockets. A transparent protective film can be made in situ over a burn, incision or wound by applying a solution of sodium alginate and then spraying with calcium chloride solution. The film is impervious to water but permeable to water vapour.