Lec 17

Blood Transfusion

Blood products:
any therapeutic substance prepared from human blood.

- Whole blood: Unseparated blood collected into an approved container containing an anticoagulant-preservative solution.

A constituent of blood, separated from whole blood, such as:

- Red cells concentrate
- Plasma
- Platelet concentrates
- Cryoprecipitate, prepared from fresh frozen plasma.

Human plasma proteins prepared under pharmaceutical manufacturing conditions, such as:

– Albumin.
– Coagulation factor concentrates.
– Immunoglobulins.

1. Whole Blood

– There have been few widely accepted indications for whole blood in modern transfusion practice.
– Whole blood is not available from most blood banks in the United States.
– Dose: 6 ml/kg of WB raise Hemoglobin level 1 g/dl.
– One unit of WB will raise the hemoglobin of an average-size adult by ~ 1g/dl.
– During donation, blood is collected into a sterile, disposable, plastic pack which contains an anticoagulant-preservative solution. This solution usually contains citrate, phosphate, dextrose and often adenine (CPDA).

Effects of storage on whole blood.

- Reduction in the pH (blood becomes more acidic).
- Rise in plasma potassium concentration (extracellular K+).
- Loss of all platelet function in whole blood within 48 hours of donation.
- Reduction in Factor VIII to 10–20% of normal within 48 hours of donation.

FUNCTION OF ANTICOAGULANT PRESERVATIVE SOLUTION IN BLOOD COLLECTION PACK

SOLUTION	Function
C SODIUM CITRATE	Bind with calcium ions in blood in exchange for the calcium salt so the blood does not clot
P PHOSPHATE	Support metabolism of the red cells during storage to ensure they release oxygen readily at tissue level
D DEXTROSE	Maintains the red cell membrane to increase storage life
A ADENINE	Provides energy source

2. Red Blood Cell

Packed RBCs are the commonly utilized blood product, providing oxygen-carrying capacity in cases most of acute or chronic blood loss.

Advantages

- Simple and inexpensive to prepare.

Disadvantages

- It has a high ratio of red cells to plasma (high viscosity) thereby increasing the time required for transfusion through a small gauge needle or cannula.
- The white cells are a cause of febrile non-hemolytic transfusion reactions in some patients.

Leukocyte-depleted red cells

- Special leukocyte filters can be used to remove virtually all the white cells.
- The majority of red cells and platelet transfusions in the United States & UK are currently leukocyte reduced.

Advantages

- Reduces acute transfusion reactions.
- Reduces cytomegalovirus infection (CMV).

Disadvantages

- Cost: special blood packs and equipment are required
- More skill and operator training are needed.

PRBCs Transfusion Guidelines

- Hemodynamic instability: Ongoing bleeding with unresponsive (or incompletely responsive) to infusion of 2- 3 Liters crystalloid
- Hemodynamically Stable:
- ICU Patients: Hemoglobin <7 g/dL
- Post-Operative: Hgb ≤8 g/dL
- Cardiovascular Disease: Hgb ≤8 g/Dl.
- Dose: 4 ml/kg of RBC increase Hemoglobin level 1 g/dl.
- One unit of RBC will raise the hemoglobin of an average-size adult by ~ 1g/dl
- Transfuse slowly for first 15 minutes.
- Complete transfusion within 4 hours.

3. White cells (leukocytes)

- White cell transfusions have no proven clinical uses.
- May be indicated in neutropenic patients with bacterial infections not responding to antibiotics.
- Transfused granulocytes have a very short circulatory life span, so that daily transfusions of 10 10 granulocytes are usually required

4. Plasma

- This is separated from whole blood and frozen at –25°C or colder within 6–8 hours of donation in order to preserve its labile coagulation factors (Factors V and VIII).
- Fresh frozen plasma can be stored for at least one year or longer if low temperatures can be maintained.
- When plasma is stored at a temperature of 2–6°C, the labile clotting activity of Factors V and VIII will decline to 10–20% within 48 hours.
- Dosage: Initial dose of 15 ml/kg.

Indications of plasma transfusion

- International normalized ratio (INR) >1.5 with:

    - Anticipated invasive procedure or surgery.
    - Massive hemorrhage (over one blood volume).
- Emergent reversal of anticoagulant (warfarin) therapy.
- Treatment of isolated factor deficiencies.
- The correction of coagulopathy associated with liver disease.

5. Platelates

- The platelet count at 1 hour post transfusion of a unit of platelets should increase by 5,000 to 10,000 platelets/µL.
- Platelets separated from plasma obtained from 4–6 donations of whole blood are often pooled to produce a therapeutic dose of platelets for an adult platelet apheresis unit, by 30,000–60,000 × 10 9/L.
- Dosage: 1 unit of platelet concentrate/10 kg body weight

Indications of platelet transfusion:

- Thrombocytopenia or Dysfunctional platelets with:
  1. Active bleeding
  2. Bleeding tendency
- Neurosurgical procedures: 100,000 platelets/µL
- Vaginal delivery and minor surgical procedures: <50,000/µL
- Massive transfusion: < 50,000 platelets/µL
- Disseminated intravascular coagulation: 20,000–50,000 /µL

6. Cryopreciptate

- Cryoprecipitate is obtained from a single donation of FFP at about 4°C and is rich in factor VIII, von Willebrand factor (VWF), factor XIII, and fibrinogen.
- Cryoprecipitate is usually administered as a transfusion of 10 single units.
- Each 5- to 15-mL unit contains over 80 units of factor VIII and about 200 mg of fibrinogen.

Blood Component Characteristic

	Red Cells	Platelet Concentrate	Fresh Frozen Plasma	Cryoprecipitate
Storage Temperature	2-6°C	20-24°C	-30°C	-30°C
Shelf Life	35 day	5 day	1 yr (frozen)	1 yr (frozen)
Volume	200-350	30-50 ml/unit	150-200ml/unit	10-15 ml/unit
Transfusion Interval	Transfuse within 30 min of removal from blood refrigerator. Transfuse unit over maximum of 4 hr	Start transfusion as soon as received from blood bank. Transfuse unit within 30 min	Once thawed, should be transfused within 4 hr	884 hr
Compatibility Testing Requirement	Must be compatible with recipient ABO and Rh D type	Preferably ABO identical with patient. Rh negative females under the age of 45 yr should be given Rh negative platelets	FFP and cryoprecipitate should be ABO compatible to avoid risk of hemolysis caused by donor anti-A or anti-B	
Administration	Infuse through a blood administration set—platelet concentrates should not be infused through blood sets that have been used for blood.			

Indications of transfusion

- Hemophilia A
- von Willebrand disease
- Hypofibrinogemia
- Uremic bleeding

Complications of blood transfusion

1) IMMUNE Complications.
2) INFECTIOUS Complications.
3) MASSIVE BLOOD TRANSFUSION Complications.

1) IMMUNE Complications

- Hemolytic reactions
  - Acute hemolytic reaction.
  - Delayed hemolytic reaction.
- Nonhemolytic reactions
  - Febrile reactions

- Urticarial reactions
- Anaphylactic reactions
- post-transfusion purpura
- Transfusion-Related Acute Lung Injury
- Graft-versus-host disease

2) Infectious Complications.

Transfusion-Transmitted Infection	Residual Risk Per Transfused Component
HIV	1 in 1,467,000
Hepatitis C	1 in 1,149,000
Hepatitis B	1 in 282,000
West Nile Virus	Uncommon
Cytomegalovirus	50-85% of donors are carriers. Leukocyte reduction is protective.
Bacterial Infection	1 in 2-3,000 (mostly platelets)
Parasitic Diseases Babesiosis, Chagas, Malaria	Relatively uncommon

3) Complications of massive blood transfusion

- Coagulopathy
- Hypothermia
- Citrate Toxicity
- Acid–Base Balance
- Serum Potassium Concentration

Immune complications

- Acute hemolytic transfusion reaction: ABO incompatibility.
- Delayed HTR: incompatible red cell antigen.
- Febrile non-HTR: anti-WBC antibodies in recipient.
- Urticarial reactions: antibody to donor plasma proteins.
- Anaphylactic: antibody to donor plasma proteins (IgA).
- Transfusion-related acute lung injury (TRALI): neutrophil antibodies in donor product.

A. Hemolytic reactions

- Hemolytic reactions usually involve specific destruction of the transfused red cells by the recipient's antibodies. Less commonly, hemolysis of a recipient's red cells occurs as a result of transfusion of red cell antibodies.
- Hemolytic reactions are commonly classified as either acute (intravascular) or delayed (extravascular).

Acute hemolytic reaction

- Acute intravascular hemolysis is usually due to ABO blood incompatibility, and the reported frequency is approximately 1:38,000 transfusions.
- The most common cause is misidentification of a patient, blood specimen, or transfusion unit.
- These reactions are often severe, and may occur after infusion of as little as 10–15 mL of ABO-incompatible blood.
- The risk of a fatal hemolytic reaction is about 1 in 100,000 transfusions.
- In awake patients, symptoms include chills, fever, nausea, and chest and flank pain.
- In anesthetized patients, an acute hemolytic reaction may be manifested by a rise in temperature, unexplained tachycardia, hypotension, hemoglobinuria, and diffuse oozing in the surgical field. Disseminated intravascular coagulation, shock, and kidney failure can develop rapidly.
- The severity of a reaction often depends upon the volume of incompatible blood that has been administered.

Management of hemolytic reaction

1. If a hemolytic reaction is suspected, the transfusion should be stopped immediately and the blood bank should be notified.
2. The unit should be rechecked against the blood slip and the patient's identity bracelet.
3. Blood should be drawn to identify hemoglobin in plasma, to repeat compatibility testing, and to obtain coagulation studies and a platelet count.
4. A urinary catheter should be inserted, and the urine should be checked for hemoglobin.

5. Osmotic diuresis should be initiated with mannitol and intravenous fluids.

Delay hemolytic reaction

Also called extravascular hemolysis, is generally mild and is caused by antibodies to non-D antigens of the Rh system or to foreign alleles in other systems such as the Kell, Duffy, or Kidd antigens. Following an ABO and Rh D-compatible transfusion, patients have a 1– 1.6% chance of forming antibodies directed against foreign antigens in these other systems.

- The hemolytic reaction is therefore typically delayed 2–21 days after transfusion, and symptoms are generally mild, consisting of malaise, jaundice, and fever.
- The patient's hematocrit typically fails to rise or rises only transiently, in spite of the transfusion and the absence of bleeding.
- The treatment of delayed hemolytic reactions is primarily supportive.

B. Nonhemolytic immune reactions:

- Nonhemolytic immune reactions are due to sensitization of the recipient to the donor's white cells, platelets, or plasma proteins.
- The risk of these reactions may be minimized by the use of leuko-reduced blood products.
    - Febrile Reactions:
    - Urticarial Reactions:
    - Anaphylactic Reactions:

C. Transfusion-Related Acute Lung Injury (TRALI):

- (TRALI) presents as acute hypoxia and noncardiac pulmonary edema occurring within 6 h of blood product transfusion.
- It may occur as frequently as 1:5000 transfused units, and with transfusion of any blood component, but especially platelets and FFP.
- It is thought that transfusion of antileukocytic or anti-HLA antibodies results in damage to the alveolar–capillary membrane.
- Treatment is similar to that for acute respiratory distress syndrome with the important difference that TRALI may resolve within a few days with supportive therapy.

D. Graft-Versus-Host Disease:

E. Post-Transfusion Purpura:

F. Transfusion-Related Immunomodulation:

G. Infectious complications

- Viral Infections: Hepatitis C, Acquired Immunodeficiency Syndrome (AIDS), Cytomegalovirus (CMV) and Epstein–Barr virus
- Parasitic Infections: malaria, toxoplasmosis, and Chagas' disease.
- Bacterial Infections: Both gram-positive (Staphylococcus) and gram-negative (Yersinia and Citrobacter) bacteria can contaminate blood transfusions and transmit disease.

Massive transfusion

- Massive transfusion, historically defined as the replacement by transfusion of 10 units of red cells in 24 hours, is a response to massive and uncontrolled hemorrhage
- Massive blood transfusion may be defined either
  - as the acute administration of more than 1.5 times the patient's estimated blood volume, or
  - as the replacement of the patient's total blood volume by stored homologous bank blood in less than 24 h.

Various definitions of massive blood transfusion (MBT) have been published in the medical literature such as:

- Replacement of one entire blood volume within 24 h
- Transfusion of >10 units of packed red blood cells (PRBCs) in 24 h
- Transfusion of >20 units of PRBCs in 24 h
- Transfusion of >4 units of PRBCs in 1 h when on-going need is probable
- Replacement of 50% of total blood volume (TBV) within 3 h.

Complications of massive blood transfusion

- Coagulopathy
- Hypothermia
- Citrate Toxicity
- Acid–Base Balance:

- High Serum Potassium Concentration14

MCQ TEST

1- Effects of storge on whole blood (all true except one)
   a) blood becomes more acidic
   b) Rise in plasma potassium concentration
   c) Loss of all platelet function
   d) Reduction in Factor VIII
   e) Rise in plasma calcium concentration

2- Acute hemolytic reaction (all true except one)
   a) Occur within hours after transfusion
   b) More severe than delay type.
   c) Due to ABO incompatibility
   d) Need supportive treatment only
   e) Acute intravascular hemolysis

3- Definition of massive blood transfusion (all true except one)
   a) Replacement of one entire blood volume within 24 h
   b) Transfusion of >10 units of packed red blood cells (PRBCs) in 24 h
   c) Transfusion of >20 units of PRBCs in 24 h
   d) Transfusion of >4 units of PRBCs in 1 h when on-going need is probable
   e) Replacement of 50% of total blood volume (TBV) within 12 h.

4- Transfusion related acute lung injury (all true except one)
   a) (TRALI) presents as acute hypoxia and noncardiac pulmonary edema
   b) occurring within 6 h of blood product transfusion.
   c) It may occur with transfusion of any blood component.
   d) Treatment is similar to that for acute respiratory distress syndrome
   e) TRALI may resolve within a few days with supportive therapy.

5- Management of hemolytic reaction (all true except one)
   a) the transfusion should be stopped immediately and the blood bank should be notified.
   b) Blood should be drawn to identify hemoglobin in plasma, to repeat compatibility testing,
   c) A urinary catheter should be inserted
   d) the urine should be checked for albumin.
   e) Osmotic diuresis should be initiated with mannitol and intravenous fluids

6- Indications of plasma transfusion (all true except one)
   a) International normalized ratio (INR) >1.5
   b) Anticipated invasive procedure or surgery.
   c) massive hemorrhage (over one blood volume)
   d) Emergent reversal of muscle relaxant drug.
   e) Treatment of isolated factor deficiencies.

7- RED BLOOD CELL transfusion guidelines (all true except one)
   a) Hemodynamic instability: Ongoing bleeding with unresponsive
   b) Hemodynamically Stable: ICU Patients: Hemoglobin <7 g/dL
   c) Hemodynamically Stable Post-Operative: Hgb ≤8 g/dL
   d) Hemodynamically Stable Cardiovascular Disease: Hgb ≤8 g/Dl.
   e) Dose: 20/kg of RBC increase Hemoglobin level 1 g/dl.