The practice of Blood Transfusion

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LEARNING OBJECTIVES

1– To know the various indications of blood and blood components transfusion.
2– Mention the various methods of blood donation, blood preservation and storage, blood transportation and methods of giving blood to patients.
3– Mention the various types of preservative solutions and the changes occurred in stored blood.
4– To be oriented about the immediate and delayed transfusion reactions and the hazards of massive blood transfusion and how to treat them.
5– To be aware about the diseases that can be transmitted by blood transfusion and how to avoid these risky complications.
6– To know the different ways of autologous blood transfusion and its advantages over homologous blood transfusion.
Introduction

An adult has about 4–6 L of blood circulating in the body, blood transport $O_2$ to various parts of the body.

Blood consists of several types of cells floating around in a fluid called Plasma.
The RBCs contain HB, a protein that binds O₂.
RBCs transport O₂ to & remove CO₂ from body tissues.
WBCs fight infection.
Platelets responsible for clot formation.
The plasma contain electrolytes & various kinds of plasma proteins:
Albumin, globulin & fibrinogen.
Definition:
A blood transfusion is the infusion of whole blood or one of its blood components such as fresh plasma, fresh frozen plasma, plasma proteins, platelets concentrates, packed RBCs and cryoprecipitate into the patient’s venous circulation.
Blood fractions

- Packed red cells
  - Packed red cells are especially advisable in patients with chronic anemia, old patients and for children.
  - Obtained by centrifugation of whole blood at 2000—2300g for 15—20 minutes.
Fresh Plasma

This is removed after centrifugation of whole blood at 2000—2300 g for 15—20 minutes and it may used as such or be further fractionated in various ways.
Fresh frozen plasma.

Plasma removed from fresh blood obtained within 4 hours is rapidly frozen by immersing in a solid carbon dioxide and ethyl alcohol mixture.

This is stored at —40°C and is a good source of all the coagulation factors: Factor IX & Factor VIII.
- **Human albumin 4.5 %.
- Obtained by repeated fractionation of plasma
- This may be **stored for several months in liquid form at 4\(^{0}\)C** and is suitable for hypoproteinaemia and following severe burns.
Platelet–rich plasma

Platelet–rich plasma is suitable for patients with thrombocytopenia who are either bleeding or require surgery.

It is prepared by centrifugation of freshly donated blood at 150—200 g for 15—20 minutes.

Platelet concentrate

Platelet concentrate are given to patients with thrombocytopenia and is prepared by centrifugation of platelet rich plasma at 1200—1500 g for 15—20 minutes.
Cryoprecipitate (Factor VIII concentrate).

- Thawing of fresh frozen plasma at 4°C; a white precipitate remains and, if the plasma is removed, this cryoprecipitate is a very rich source of Factor VIII.
- It is stored in liquid form at —40°C.
- Used for treatment of patients with hemophilia (Factor VIII deficiency).
- It is also a rich source of fibrinogen, of value in hypofibrinogenenaemia.
- Factor VIII concentrate and Factor IX concentrate.
  - They are stored in freeze-dried form (Powder).

- Fibrinogen.
  - Fibrinogen is prepared by fractionation of plasma and stored in the dried form.
  - Reconstituted with distilled water, it is used in patients with severe depletion of fibrinogen (e.g. DIC or congenital afibrinogenaemia).
Indications

1. Replacement of blood loss after accidents.
2. Hemorrhage from pathological lesions e.g. from esophageal voices.
3. During major operations e.g. abdomino-perineal and cardiovascular surgery.
4. Following severe burns due to associated haemolysis.
5. Preoperatively i.e. correction of chronic anemia.
6. For patients with hemorrhagic disorders such as thrombocytopenia, hemolytic anemia or chronic liver disease.
Collecting, Storing & Transporting blood

Red Blood Cells

Platelets
Collecting blood
1) Collecting blood :-

- The donor should be fit with no history of hepatitis or AIDS.
- Blood is collected into a sterile plastic bag containing 75 ml anticoagulant solution.
With the donor lying on a couch, a sphygmomanometer cuff or tourniquet is applied to the upper arm and inflated to a pressure of **80 mm Hg** to occlude the superficial veins.

After locally injecting **0.5 ml** local anesthetic (**xylocaine 2%**), the 15 gauge needle is introduced into the median cubital vein, and **410 ml of blood** allowed to run into the bag. (**410 + 75 = 485ml.**)
During collection, blood is constantly mixed with the anticoagulant.

At the end of the procedures, samples of donated blood are obtained and sent for blood grouping and cross matching.

The donor is left supine for 15 min. and is given an appropriate beverage.
Preservation of blood
Anticoagulation and preservatives for blood products

✓ To ensure the viability and stability of the products

✓ To inhibit growth of microorganisms

✓ To prevent clotting of the product
The preservative solutions

1) The citrate phosphate dextrose sol (CPD)
   - CPD almost completely replaced ACD (acid phosphate dextrose) as blood preservative sol.
   - It allows 28 days for safety blood storage.

2) Citrate phosphate dextrose adenine –1 sol.(CPDA–1).
   - RBCs are dependent upon ATP as an energy source, the availability of adenine appears to be essential for the maintenance of levels of 2,3 diphosphoglycerate (DPG)
   - CDDA–1 allows a period of 35 days for safe blood storage.
3) Citrate phosphate dextrose adenine–2 sol (CPDA–2).

- It has the same composition of CPDA–1 except that CPDA–2 contains 1.4 times more glucose and 2 times more adenine than CPDA–1.
- CDDA–2 allows a period of 45 days for safe blood storage.

- This sol. was described by Valeri et al 1983 for preserving red blood cells for 49 days.
- However, recent studies have shown that the only accepted RBCs survival was obtained after 35 days preservation in ADSOL.
Storage of blood
- Blood is stored in a blood bank refrigerator controlled at 4°C ±2.

- It should not be allowed to stand at higher temperature for more than 2 hours.
Storage affects blood in different ways:

1 – RBCs

Normally, the average life span of RBCs is **120 days**.

In storage, RBCs produce copious amounts of **lactic acid** from glucose metabolism even at low storage temperature.

The fall in PH of stored cells, results in **loss of their 2,3 diphosphoglycerate (DPG)** which is necessary for oxygen delivery.
Progressive release of **lactic acid** stop of glycolysis of the stored RBCs (*the PH sensitive hexokinase and phosphofructokinase steps*)

- The erythrocyte loses its capacity to survive.
- RBCs stored for long periods show marked increase in osmotic fragility.
- Changes in the intracellular cation content (decrease in K and increase in Na.)
2 – Platelets:

The average life span in vivo is 7–10 days.

In storage, many studies have indicated that platelet viability is best maintained at 22 °C rather than 4 °C.

Platelets stored at 22 °C are suitable for use after 3–4 days.

While those stored at 4 °C can not be used after 24 hours, because few are still functioning.
Platelets are currently stored in new bags "polyvinylchloride" which is permeable to gases allowing O2 to enter and Co2 to escape.

By these new bags, there will be little changes in PH with minimal changes in platelets.
Effect of storage (cont)

3– White blood cells:
- Rapidly destroyed in stored blood.

4) Coagulation factors:
- Most of plasma coagulation factors are completely stable. (even in plasma of outdated blood)
- Except; the labile factors V & VIII, their decay is accelerated in acidic PH.
Appropriate storage temperatures

1 to 6°C  WBCs and packed RBC
≤ -18°C  FFP
20 to 22°C  Platelets
≤ -18°C  Cryoprecipitate
Transport of blood for places away from the blood bank refrigerator, should be carried out in **containers of ice chips** so that the temperature can be held at 4°C.
1) Antigens of the ABO blood groups:
- They are associated with naturally occurring antibodies in the serum:
- **Blood group O** –ve can be transfused to all other groups (general donor)

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<tr>
<th>A</th>
<th>Anti B antibodies</th>
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<tr>
<td>B</td>
<td>Anti A antibodies</td>
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<td>AB</td>
<td>No antibodies</td>
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<tr>
<td>O</td>
<td>Anti A &amp; Anti B</td>
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2) Antigens of the rhesus blood groups

Rh (D) antigen is present in 85% of population (Rh+ve)

Antibodies (anti D) are not naturally present in the remaining 15% (Rh–ve)

Rh–ve can be stimulated by transfusion of Rh+ve blood.

Anti D antibodies are capable of crossing the placenta (during pregnancy) & if the mother is originally Rh – ve, the baby will have severe haemolysis & even death (hydrops foetalis)
3) Other antigens of the kidd system

E, C & Fy may be associated naturally with antibodies and are responsible for incompatibility reactions in rare occasions.
Cross matching

1– Direct matching of the recipient's serum with the donor RBCs to confirm ABO compatibility.
2– Test for Rh and any other blood group antibody present in the serum of the recipient.
3– Test for viral hepatitis antigens and antibodies (B–C) & for HIV.

N.B:
1) Blood grouping & cross matching require usually one hour but in emergency it is necessary to reduce this time.
2) The most common cause of a transfusion reaction is human error.
Giving blood

1 – Selection of the site
Select a superficial vein of good caliber, away from joints and Compression sites.

2 – Careful checking of the donor blood
The blood bag should contain pat's name, hospital reference No., ward & blood group.
3– Warming blood to a temp of 37°C in a blood warming unit but not by means of hot water.

4– Insertion of needle of blood filter; 40 um into vein of good caliber to maintain the required rate of transfusion.

Filtering the blood through filters of 40 um will prevent platelet aggregates and other particles from entering the circulation.
GIVE BLOOD, GIVE LIFE!
Complications

Transfusion Reactions

Acute Reactions

Delayed Reactions
Acute Reactions

- Allergic and febrile reactions
- Sepsis/Bacterial Contamination
- Acute Hemolytic Reactions
- Circulatory Overload
- Hazards of massive transfusions
Acute haemolytic reactions

1 – Antibody mediated haemolysis
   Immediate haemolysis (intra and extra vascular)
   Delayed haemolysis

2 – Non immunologic haemolysis
Acute haemolytic reactions

1 – Antibody mediated haemolysis

1 – Immediate haemolysis:

intra-vascular & extra-vascular (In RE system)

Incidence:–

- Acute hemolytic reactions 1 / 25000
- delayed haemolysis 1 / 2500

Antibodies (A & B agglutinins) damage red cells in one of two ways:

1 – By initial attachment of a complement (C) to the cell membrane with subsequent activation of complement components.

2 – By remaining attached as immunoglobulin on the surface of red cells leading to an accelerated destruction in the R.E. system
A hemolytic transfusion reaction can lead to:

1. Renal damage
2. Disseminated intravascular coagulation (DIC).

The most common clinical manifestation of a hemolytic transfusion reaction is **Oliguria**

- Rigors, Nausea
- Lower back pain
- Chest pain or tightness
- Acute hypotension or hypertension
- Tachycardia, Tachypnea
Management

1–Stop transfusion.
2–A sample of venous blood & urine is sent, with all the remaining blood from the unit, to the laboratory for checking.
3–Administer 100 ml of 15% mannitol as rapidly as possible i.v to promote diuresis.
4–Administer 40 mmol sod. bicarbonate i.v (To buffer acidosis)
5–Keep an eye on the pat's pulse, Bl.P. and urine output.
2– Non immunologic haemolysis

Destruction of compatible donor red cells may occur if the cells are already damaged prior to transfusion.

1– Excessive fluctuation of storage temperature
2– Warming blood in a pan of hot water to 50°C.
3– Freezing of the stored blood.
4– Excessive pressure during transfusion, esp. through small bore needles.

All these factors will damage the RBCs and initiate haemolysis.
Sepsis/Bacterial contamination

**Treatment**:  
Maintain airway  
Diuretics  
Hydration (IV fluids)  
IV broad spectrum antibiotics.
Transfusion–Associated Circulatory Overload (TACO)

**Treatment**

- Upright posture
- Maintain airway; provide oxygen and ventilatory support if necessary
- Diuretics (furosemide)
A febrile (pyrogenic) non hemolytic reaction (temp. increase by 1 degree or more) is the most common immediate transfusion reaction.

It is due to (incompatible white cells)

The interaction of recipient anti leukocyte antibodies with the transfused donor leukocytes.

When fever predominates, there is usually rigor, vomiting, tachycardia & occasionally circulatory collapse.
Allergic reactions: Anaphylactic Reactions

It is a reaction to the plasma proteins

Presents by bronchial asthma & may be pulmonary edema.

Treatment:

- Maintain airway; provide oxygen and ventilatory support if necessary
- Stop the transfusion.
- Treat hypotension – Trendelenberg position and IV fluids
- Give 100 mg hydrocortisone IV
- For anxious pat's give 10 mg morphia
- Give 10 mg chlorpheniramine (anti histaminic) IM
Hazards of massive transfusions

- Massive transfusions: more than 10 units of blood to an adult in a period of 24 hour period.
- 1 – Rapid transfusion of large volumes of **cold blood** (1–6°C) can lower the body temp and induce **cardiac arrhythmias**.
- 2 – Massive transfusion of **stored blood** can lead to increased acidity & hyperkalemia.
3– Prolongation of clotting time due to hypocalcaemia.
4– Citrate toxicity.
5– DIC will lead to further loss of platelets and consumption of factor V&VIII, prothrombin and fibrinogen.
6– Post – transfusion thrombocytopenia will lead to purpura and bleeding.
7– Congestive heart failure.
Delayed Reactions

- Post-transfusion Purpura (PTP)
- Transmitted diseases
- Delayed Hemolytic Reactions
- Blood group immunization
1– Delayed haemolysis

- In incompatible blood transfusion, the conc. of antibodies in the recipient's blood may be too low to cause rapid haemolysis.
- A few days (2–8 days) after the second transfusion, there is a rapid increase in antibody conc. & rapid red cell haemolysis.
- The antibodies that more often cause delayed haemolysis are:
  
  Anti E – Anti C & anti Fy
Clinically;

- Unexplained fever and dropping of the pat's Hb. Level and hematocrit
- Jaundice, ↑ Lactate dehydrogenase (LDH)
- Leucocytosis may occur

Treatment:
- Send a new blood specimen for antibody identification
- Monitor renal function
2- Transfusion – associated diseases

1) The acquired immune – deficiency syndrome (AIDS)
Due to the human immunodeficiency virus (HIV)
This virus is capable of destroying T- helper lymphocytes decrease in B – cell antibody response..
HIV infection can be transmitted by blood & blood products.
Once the virus is caught, the victim harbors it for life.
Patients with AIDS are classified into 4 main groups:

1– Asymptomatic carriers (Incubation period from 6 months to 6 years)

2– Pat's with generalized lymphadenopathy.

3– Pat's with AIDS related complex: fatigue, fever & impairment of the immune system.

4– Pat's with fully expressed AIDS: Symptomatic with threatening opportunistic infections & Kaposi's sarcoma.
To minimize the risk of AIDS transmission through blood transfusion

- Blood banks should do **screening for HTLV III antibody** using the current **ELISA test**.
- Units found to be positive by ELISA test, should be tested for **HIV antigen** by the Western blot test or radio immune precipitation tests;
2– Viral hepatitis

In the past, 5–6% of all blood recipient had subclinical post – transfusion hepatitis.

- Since the implementation of testing the donor units for anti Hep. C and Hep. B antigen, the risk of post transfusion hepatitis is now reduced to 1/200 transfusion (0.5%).
- The most common fatal infectious complication of a blood transfusion is viral hepatitis
- Hepatitis virus is transmitted by whole blood and any of its components.
3–Blood group immunization

- Blood transfusion exposes the recipient to different types of antigen, any of which may stimulate anti body formation.
- Antigens A & B as well as Rh antigen are highly immunogenic.
- Leukocytes & platelets are also immunogenic, stimulating formation of anti HLA & anti platelet antibodies.
- Those patients develop incompatibility reactions on further transfusions.
- NB: Individuals who develop antibodies to donated white cells & platelets should not be given whole blood but only packed washed red cells.
4–Posttransfusion Purpura (PTP)

It is due to incompatible platelets

- Clinically:
  Thrombocytopenia, which may be severe, occurring suddenly 1–2 weeks after a transfusion
  - Skin rash, melena, haematuria, vaginal bleeding
Treatment
• Intravenous **immune globulin** (iv IG)
• **Steroids**, although their benefit has not been documented
• Send blood specimen to laboratory to check for **platelet antibody**
To avoid these hazards,

*Autologous blood transfusion*
Autologous blood transfusion is a process when a person receives his own blood for a transfusion, instead of banked donor blood.
Types

**Predonated blood:**

1- Pre-deposit (banked) autologous blood
2- Preoperative blood donation, (haemodilution)

**Blood salvage** using the Cell Saver machine.

1- Intra operative auto transfusion
2- Extra operative autotransfusion (haemothorax)
3- Post operative auto-transfusion
Cell saver machine

Autotransfusion Process Diagram

- Anticoagulant
- Shed Blood
- Collection Reservoir
- Patient
- Wash Solution
- Valve
- Pump
- Waste
- Centrifuge Bowl
- Waste Bag
- Reinfusion Bag
- Vacuum
Preoperative blood collection
(banked autologous blood)

- By this method, one or more units of blood are collected before an elective surgery for re-infusion during or after the procedure.
- You can collect & store whole blood, RBCs, plasma & or platelets for later re transfusion into the same person.
Several techniques are used

1 – Frozen Red cells

Blood is collected many months, or even years before surgery at internals to be stored in the form of frozen RBCs at -85°C with "glycerol" added to it.

Frozen Red cells can be stored for 3 years.
2– The leap – frog technique:

Several units are collected starting 3 or 4 weeks before surgery.

One week after the initial donation, you have to collect 2 units while re-infusing the first units.

This can be repeated every week to collect up to 4 units of blood with out outdating.
3– The every week donation program

This program is designed to collect blood from the eligible pat. at weekly interval starting as far as 35 days before surgery, where CPDA-1 is used as preservative.
However, who can tolerate the every week donation should have initially adequate body stores of iron & an active bone marrow.

The accepted Hb level to start autologous blood donation is 11 g%.

All patient are given iron and vitamins after donation to encourage haemopoiesis.
Advantages of Autologous Blood Transfusion

1- No transmission of diseases
2- No allo-immunization of the pat. to the constituents of his own blood.
3- The state of slight haemodilution produced after blood donation can improve microcirculation and increase or maintain O2 delivery to the tissue and protect against post-operative thrombosis.
4- Greater availability of homologous blood in blood bank pool for other pat's who can not donate blood.

5- It is of special importance to pat's rare blood groups & Rh –ve

6- No delay of surgery because of blood shortage.
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