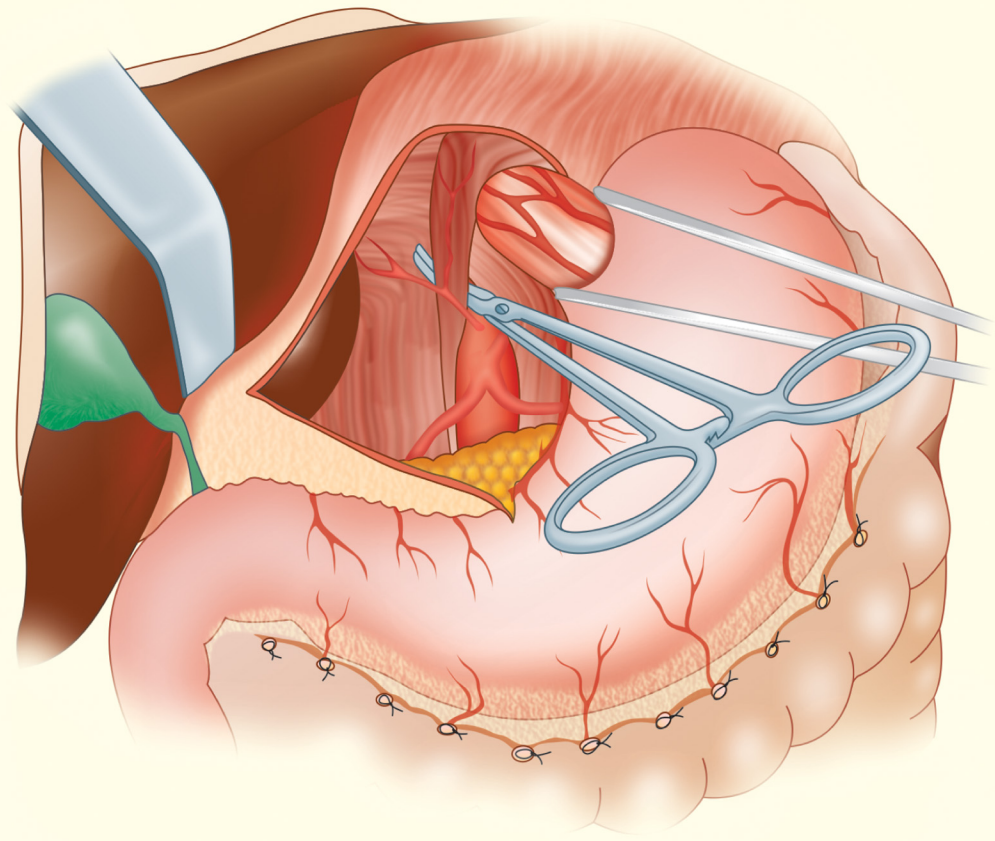
Short Textbook of
SURGERY

With Focus on Clinical Skills

A Core Text Including Long & Short Cases, Operative Surgery and Viva with Orthopedics & Fractures



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Foreword
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Chapter 3

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- Estimation of the amount of blood loss
- Blood transfusion
- Massive transfusion
- Plasma and blood substitutes
- Preservation and storage of blood
- Preparation for blood transfusion – blood grouping, antibody screening and cross-matching
- Hazards or complications of blood transfusion
- Autologous transfusion

HEMORRHAGE

Hemorrhage is usually a serious matter and its control is one of the important duties of a surgeon. He should be able to detect the source of the bleeding and to estimate its amount. Further he should know how to stop the bleeding and restore the blood lost by fluid and blood transfusion.

Types of Hemorrhage

Hemorrhage may occur from an artery, from a vein or from capillaries.

Arterial Hemorrhage

Arterial blood is bright red and comes in a spurting jet which rises and falls in time with the pulse. If bleeding continues for a long time and especially when electrolyte solutions are given as a replacement of blood loss, the blood can become quite watery in appearance.

Venous Hemorrhage

If the blood is coming from a vein, it is dark red and flows steadily without spurts. It is not the fact that bleeding from veins poses a lesser problem than hemorrhage from high pressure arteries. Hemorrhage from large and especially deep seated veins, e.g. the common femoral or jugular, can tax the ingenuity of the most experienced surgeon and therefore should not be taken lightly.

Capillary Hemorrhage

Is bright red and may be quite a rapid ooze. If continuing for many hours, blood loss can become serious, as in hemophilia.

Hemorrhage from a Wound

When a wound is sustained, either due to operation or trauma hemorrhage may take place immediately, after a few hours or after a few days. Depending upon the time at which it occurs, it is classified as follows.

1. Primary hemorrhage is that which takes place at the time of the injury or operation.
2. Reactionary hemorrhage usually occurs within 24 hours (average 4-6 hours) and is most commonly due to slipping of a ligature or dislodgement of a clot. Alternatively it may occur due to the fact that the artery went into spasm at the time of the injury but later the spasm passed off, with resulting hemorrhage.
3. Secondary hemorrhage takes place one or two weeks after the injury or operation and is due to infection and sloughing of part of the wall of an artery.

Predisposing factors are pressure of a drainage tube, the presence of a fragment of bone, a ligature in an infected area and cancer. It is also a complication of arterial surgery and amputations. There may be 'warning' hemorrhages in the form of bright red stains on the dressing followed by a sudden severe hemorrhage. A warning hematemesis may occur in the case of a peptic ulcer and is a danger signal that is not to be ignored. In advanced cancer, the erosion of a main vessel, e.g. carotid or uterine by a locally ulcerating growth may result in quick and merciful termination of the patients life.

Secondary hemorrhage is especially common after anorectal operation. This is due to the presence of a certain degree of infection along with moisture which causes maceration of the tissues. Hemorrhoidectomy wounds are especially prone to this complication because they involve division and ligation of the arteries supplying the piles.

External and Internal Hemorrhage

External hemorrhage: Is visible, that is, revealed hemorrhage, e.g. when the femoral artery is cut across. The quantity of blood lost is easy to estimate, in such a case.

Internal hemorrhage: Is invisible or concealed hemorrhage as in the case of rupture of the spleen, ruptured ectopic gestation

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or fracture of the femur. In certain cases, concealed hemorrhage can become revealed as in hematemesis or melena from a peptic ulcer or hematuria following blunt trauma to the kidney.

Clinical Features of Hemorrhage

The signs and symptoms of blood loss are as follows: there is increasing pallor and a rising pulse rate. The patient is restless and in advanced cases there are deep sighing respirations, a condition, which is called air hunger. The skin is cold and moist, the veins are empty and there is thirst.

Pulse and BP should be recorded every 15 to 30 min. When they stabilize they can be recorded every 2 to 4 hours. The BP is normal at first and falls only after a good deal of blood has been lost. Therefore, even if the blood pressure is normal it is possible that severe hypovolemia may be present. In such a situation the BP is maintained by shutting off large parts of the vascular bed by vasoconstriction in the nonessential organs.

Any further loss of blood volume can lead to sudden collapse and even death.

It is therefore, important to palpate the hands and feet to see if they are warm or cold. If they are warm it means, there is no vasoconstriction and implies that the blood volume is sufficient. On the other hand cold extremities indicate serious hypovolemia with respect to the volume of blood lost.

Hemorrhage can also be classified as follows:

Class I hemorrhage: With loss of blood less than 15 percent of total blood volume (TBV). This produces very little effect on pulse or BP.

Class II hemorrhage: With loss of 15-30 percent of TBV, produces tachycardia and decreased pulse pressure.

Class III hemorrhage: i.e. loss of more than 30 percent of TBV with tachycardia, tachypnea, hypotension, oliguria and impaired mental status.

Replacement: Blood loss of upto 20 percent of TBV should be replaced with crystalloid solutions like Ringer's lactate, 20 to 50 percent loss with crystalloids and red blood cell concentrate and loss greater than 50 percent with crystalloids, red blood cells and albumin or plasma.

ESTIMATION OF THE AMOUNT OF BLOOD LOSS

Before the blood loss during a hemorrhage is replaced, the clinician should arrive at a rough estimate of the amount of blood lost. It is not always easy to estimate the exact amount of blood lost during trauma or operation. However, the following guidelines may be helpful.

(i) Blood clot—A blood clot of the size of a closed fist is about 500 ml in volume.

(ii) Swelling in closed fractures — In fracture of the tibia, if a moderate degree of swelling is present, 500 to 1500 ml of blood may have been extravasated into the muscles. In a fracture of the femur as much as two liters of blood may be lost into the tissues.

(iii) Swab weighing—Perhaps the best method of estimating blood loss during operations is to weigh the swabs used to mop up the blood and to deduct their preoperative weight. The resulting total obtained (1 gm = 1 ml) is added to the volume of blood collected in the suction or drainage bottles. A delicate weighing scale is required for this purpose. In extensive operations such as radical mastectomy or partial gastrectomy, the swab weighing total should be multiplied by a factor of 1.5 and for even more extensive operations like abdominoperitoneal resections of the rectum by 2. This is because the blood, plasma and water are lost from the vascular system because of evaporation from open wounds into the tissues and through sweating and expired water via the lungs.

(iv) Measurement of the hemoglobin level, the hematocrit (Hct), central venous pressure (CVP), cardiac output and urine output.

All of the above parameters are reduced in severe hemorrhage. Hence, their measurements will provide an estimate of the amount of blood loss.

Treatment

Treatment of hemorrhage is divided into two parts viz. the arrest of bleeding and the replacement of the lost blood.

I. Arrest of bleeding or hemostasis: The following are the surgical means of hemostasis.

(a) Pressure and packing: The first aid treatment of hemorrhage from a wound is application of pressure dressing made from anything soft and clean. The dressing or pack should be bound tightly.

The forefinger and thumb or roller gauge pack is used to control epistaxis.

Double balloon in the esophagus and stomach is used to control the bleeding from the esophageal varices by the pressure of the inflated balloons.

(b) Position and rest: Elevation of the limbs, e.g. the patient with varicose veins employs gravity to reduce bleeding. Elevation also helps in vasoconstriction.

(c) Operative techniques.

- Artery forceps (Hemostats) and clips are mechanical means of controlling bleeding by pressure. The clamped vessel can be ligated with catgut, cotton, silk etc. or it can be coagulated with diathermy.
- The part or whole of a bleeding viscus may have to be excised for example splenectomy or partial hepatectomy.

A ruptured kidney is treated conservatively if possible.

II. The replacement of the lost blood— This is carried out by blood transfusion or by infusion of plasma substitutes or expanders, e.g. albumin, dextrans like dextran 70 or dextran 40 and gelatin, e.g. hemaccele, gelofuschine, etc.

BLOOD TRANSFUSION

Introduction

Blood transfusion can be a life–saving procedure. However, it can also be followed by serious reactions due to incompatibility and otherwise. Therefore, blood should be transfused only when really indicated and stringent precautions should be taken before and during the transfusion. This is all the more important because of the rising incidence of AIDS and hepatitis, along with intravenous drug abuse.

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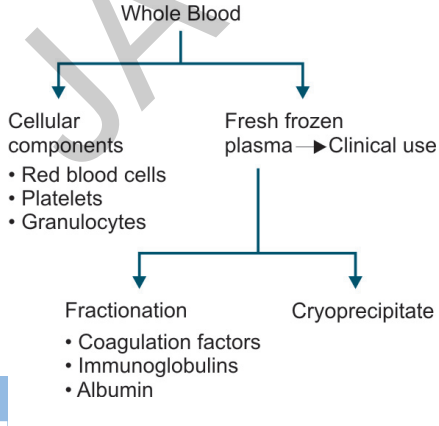
Indications for Blood Transfusion

1. Following hemorrhage which may be due to:
   i. Trauma with severe blood loss.
   ii. Bleeding from pathological lesions, e.g. from the gastrointestinal tract.
   iii. Major operative procedures in which a fair amount of blood is lost, e.g. radical mastectomy or abdominoperineal resection.
2. After extensive burns where a good deal of blood is lost in the burnt skin.
3. Postoperatively in a patient who has become severely anemic from infection.
4. Preoperatively in a patient who has become severely anemic and surgery is indicated urgently, i.e. when there is inadequate time for effective iron or other replacement therapy or if the anemia is unresponsive to therapy, e.g. aplastic anemia.
5. In a patient with bleeding disorder, e.g. Hemophilia or thrombocytopenia either to prevent hemorrhage or to arrest it.

Blood Components and Products

During the early years of blood banking the whole blood was exclusively used for transfusion. But in recent times, most blood collected from donors is processed into blood components and products. By this the patient gets the maximum benefit at a minimum risk and the components thus saved are conserved for other patients.

The term blood component includes the various parts of blood that are separated by conventional technology like centrifugation, freezing and thawing, etc. or by cell separator machines. When more sophisticated chemical or manufacturing processes are involved, the term plasma derivatives or fractions are used.



Whole Blood

Whole blood should be reserved for acute blood loss even here packed red cells plus crystalloid or colloid solutions are acceptable alternatives.

Packed Red Cells

Red blood cell concentrates or packed cells consist of whole blood from which the plasma has been removed volume of one unit is 350 ml. and shelf-life 35 days at 4°C.

Washed RBCS are used in patients who cannot tolerate granulocyte and platelet debris normally present in RBC concentrates.

Indications

Patients with chronic anemia with Hb < 7 gm per dl.

In elderly patients, small children and patients in whom introduction of large volumes of fluid may cause cardiac failure.

Packed red cells are suitable for most forms of transfusion therapy including major surgery especially in association with clear fluids.

Platelet Rich Plasma and Platelet Concentrates

These are:

- Platelets suspended in plasma.
- Shelf-life is 5 days at room temperature (22°C).
- They are used to treat patients with severe thrombocytopenia; platelet count should be raised to 100000 to prevent bleeding in the thrombocytopenic patient.
- It is desirable to use platelets that are ABO or Rh compatible. Since the concentrate contains red cells Rh+ve donors should not be used for Rh–ve recipients.
- Platelet transfusion may result in transfusions of the hepatitis virus.
- Platelet transfusion are ineffective in some situations like (i) Multiple transfusion, here the platelets may be destroyed by alloantibodies (ii) When the cause of thrombocytopenia is destruction by autoantibodies (iii) In DIC (iv) In hypersplenism.

Granulocyte Transfusions

These are useful in patients who are neutropenic to prevent and treat infections. Extraction of large number of leukocytes from donors can be accomplished by continuous flow blood separators employing differential centrifugation or Nylon fiber filter systems. It has a very short shelf-life of 24 hours at room temperature.

Albumin 4.5%

Repeated fractionation of plasma by organic liquids followed by heat treatment results in this plasma fraction. It has the advantage of being free from the risk of producing hepatitis. It is a colloid solution, useful in shock due to burns, acute pancreatitis and intestinal obstruction. However, it has limited availability and expensive.

Fresh Frozen Plasma ⇒ FFP

- It is a good source of all the coagulation factors prepared by centrifugation of donor whole blood within 4 hours of collection and frozen at –30°C.
- Shelf life of 12 months at –30°C.
- A unit is typically 200 – 250 ml.
- Should be used within 1 hour of thawing.
- Indications of FFP transfusion.
  i. In patients with multiple coagulation defects resulting from hepatic insufficiency.
  ii. In DIC (Disseminated intravascular coagulation).
  iii. Where labile clotting factors (V and VIII) have been depleted by the transfusion of very large volumes of old stored blood.

Cryoprecipitate ⇒ Cold Coprecipitate

- This is produced by slow thawing of FFP at 40°C. This is rich in factors VIII, XIII, fibrinogen and VWF.
- Shelf-life of 12 months at –30°C
- Indications:
  i. In the treatment of patients with hemophilia. The advantage of cryoprecipitate is its simplicity of administering large quantities of factor VIII in relatively small volumes by IV injection.

Factor VIII Concentrate

It is used for treatment of hemophilia and von Willebrand disease.

Factor IX Concentrate

Contains factor IX, X and XI. It is used in the treatment of hemophilia β (Christmas disease) and congenital deficiencies of factors X and XI. When combines with factor

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VII concentrate it is more effective than FFP in the treatment of severe hemorrhage due to excessive warfarinization and liver disease.

SAG – Mannitol (SAG – M) Blood

Because of the increasing need for blood products, the use of SAG–mannitol (SAG–M) is becoming more common. Whole blood from which plasma has been removed and replaced by a crystalloid solution of sodium chloride, Adenine, Glucose anhydrous and mannitol is being used. This procedure maintains good cell viability but the product contains practically no protein (albumin). In the case of top up transfusions for anemia, this will not constitute a problem.

In healthy adults, the plasma albumin level will not be compromised by a replacement transfusion of upto four units of SAG – M blood, after which whole blood should be used. If this is not available, more SAG – M blood may be given supplemented by one unit (400ml) of 4.5 percent human albumin solution for every two units of SAG – M blood. After eight units of SAG – M red cells have been transfused, the need for FFP and platelets should be considered, after first checking the coagulation status and platelet count.

MASSIVE TRANSFUSION

It is defined as transfusion of total blood volume in less than 24 hours.

Complications

1. Bleeding—Massive transfusion of stored blood can produce dilutional effect on platelets and clotting factors, especially factors V, VIII, IX. FFP should be given prophylactically and platelet concentrates if level is < 50×10^9/liter.
2. Metabolic acidosis due to acid load in stored blood.
3. Hyperkalemia—In the absence of renal failure this usually does not pose a problem.
4. Fall in 2-3 PG level—This leads to a less efficient oxygen delivery. With CPD anticoagulant, however this problem is reduced.
5. Hypothermia—Blood warmer to be used.
6. Citrate toxicity—This occurs because of finding of ionized Ca^{++} and results in cardiac toxicity, tetany, etc.
7. Adult respiratory distress syndrome (acute lung injury).
8. DIC (Disseminated Intravascular Coagulation).

PLASMA AND BLOOD SUBSTITUTES

Plasma Substitutes

Colloids are regarded as plasma substitutes. They donot dissolve into a true solution and can not pass through a semipermeable membrane, contain high Mol. Wt–molecules and remain in the intravascular compartment longer than crystalloids, providing the oncotic pressure.

Use: If massive bleeding has occurred or is taking place, the lost blood must be replaced promptly. If blood is not available, immediately, at least the normal blood volume must be reestablished, using one of the following plasma substitutes available.

1. Albumin 4.5 percent ⇒ vide above
2. Dextrans — Are glucose polymers of different molecular-weights producing an osmotic pressure similar to that of plasma. They induce rouleaux formation of the red blood cells and therefore, interfere with blood grouping and cross matching. So the blood sample for these tests must be taken before dextran is infused.
   - Dextran 40 (Average Mol. Wt. 40,000), called Low Mol. Wt. Dextran (Lomodix).
   - Dextran 70 (Average Mol. Wt. 70,000), also called High Mol. Wt. Dextran.
   - Half life – 16 hours.
     Dextran 40 is filtered by the kidney but Dextran 70 is not therefore Dextran 70 stays in circulation longer.
   - Dextrans interfere with platelet function and may be associated with abnormal bleeding and the total infusion should not exceed 1000 ml.
3. Gelatins (hemaccel/gelofusin)
   - Half life – 8 to 10 hours.
   - There is low incidence of allergic reaction.
   - Mol. Wt. – 30,000.

   Hemaccel contains K^+ and Ca^{++} therefore, if mixed with citrated blood in a giving set leads to coagulation.

Advantages of plasma substitutes are that they are relatively nontoxic, inexpensive, can be stored at room temperature, do not require compatibility testing and do not transmit infections.

Adverse effects include anaphylaxis, fever, and rash. Such effects being more frequent with starch based products.

Red Cell/Blood Substitutes

Two groups of substances are considered:

Hemoglobin Solutions

- Early attempts to prepare hemoglobin solutions consisted of pooling outdated blood, breaking open the RBCs, and extracting the hemoglobin molecules. This solution is termed stroma-free hemoglobin.
- The hemoglobin solutions are polymerized and pyridoxylated because normal Hb outside the red blood corpuscles become dimer from the tetrameric form and excreted by the kidneys and these problems can be overcome by pyridoxylation. The resultant solution has the same oxygen carrying capacity as normal blood.
- Clinical trials are underway to determine the efficacy of the solutions for acute blood loss and perioperative applications.
- Recently hemoglobin based RBC substitutes have been produced from bovine hemoglobin, human hemoglobin and recombinant hemoglobin.

Perfluorocarbons (PFCs)

PFCs are good solvent for all gases. About 40ml of O_2 will dissolve in 100 ml of PFC. Several PFCs have been tested in humans with limited success. The long-term effects on liver and immune system are not known.

PRESERVATION AND STORAGE OF BLOOD

Blood is a fluid which perfuses all organs and tissues in the body. It is a vehicle for nutrients, oxygen and waste products from metabolic activity. It transports hormones, coagulation factors and antibodies.

Banked Whole Blood

Deleterious changes occurring during storage:

i. Decreased red cell survival: During storage red cells progressively loss their

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capacity to survive in a recipients circulation, after transfusion. Thus if a 14 day old stored blood is used, 50 percent of red cells will survive 60 days after transfusion, whereas only 25 percent of the RBCs will survive 60 days if a 28 day old stored blood is used.

ii. There is loss of cellular ATP which is one of the major factors in the decline in cell viability.

iii. There is decreased concentration of 2 to 3, Diphosphoglycerate(DPG) in RBCs and this is associated with shift of the oxygen dissociation curve to the left so that oxygen is less readily given up to the tissues.

iv. pH changes from 7.0 to 6.88 due to acid load (Lactic acid increases from 20 to 150 mg/dl in 21 days).

Anticoagulants in Use

- ACD (Acid-citrate dextrose) — It is a mixture of citric acid, trisodium citrate and dextrose and has been used for many years. But this is now replaced by CPD.
- CPD (Citrate phosphate dextrose) — It is mixture of citric acid, trisodium citrate, sodium dihydrogen phosphate and Dextrose. It is less acid and viability of red cells is better preserved.
- CPDA — It is a citrate – phosphate – dextrose – adenine mixture. The ATP content of stored red cells can be largely restored by incubation with adenine, and the inclusion of adenine in the anticoagulant mixture improves the maintenance of red cell viability. Hence, CPDA is now commonly used.

Temperature at which blood is stored is -4°C. At temperature above 10°C, there is rapid deterioration of red cells.

Components of a Unit of Blood

- One unit (pint) of blood contains 450 ml of blood and 63 ml of CPDA anticoagulant. The number of red cells is such that transfusion of one unit of blood will raise Hb level by 1 gm/dl.
- Granulocytes are not viable in stored blood.
- Platelets are viable only if the blood is less than 24 hours old.
- Clotting factors II, VII, IX, and XI are stable in stored blood while labile factors V and VIII rapidly deteriorates at 4°C but are stable in fresh plasma and cryoprecipitate when stored frozen at -30°C.
- Each unit of blood contains 10 gm of Albumin, 2 gm of gammaglobulin and 0.7 gm fibrinogen.

PREPARATION FOR BLOOD TRANSFUSION – BLOOD GROUPING, ANTIBODY SCREENING AND CROSS-MATCHING

Routinely the entire blood grouping and cross matching procedure takes at least 2 hours even if no difficulties are encountered.

ABO Grouping

Genes for the antigens of the ABO blood group system (A and B antigens) is located on the long arm of chromosome 9.

ABO blood grouping at room temperature is done routinely. The red cells are centrifuged and plasma is discarded. The cells are washed by repeated suspensions in normal saline followed by centrifugation and discarding the supernatant.

A 2 percent suspension of cells in normal saline is prepared. One drop of cell suspension and one drop of patient's serum on a slide are gently agitated and agglutination observed. Agglutination means antigen - antibody reaction has occurred. Type 'O' red blood cells have no agglutinogens and therefore, do not react with either anti-A or anti-B serum. The table below illustrates the presence (+) or absence (–) of agglutination with each of four different types of blood.

Red blood cell type	*Sera*	
O	*Anti A*	*Anti B*
	–	–
A	+	–
B	–	+
AB	+	+

Type A blood has A agglutinogens (antigen) and therefore agglutinates with anti - A agglutinins (antibody). Similarly type B blood agglutinates with anti B serum. Type AB has both A and B agglutinogens and agglutinates with both types of serum.

Rh Grouping

In 1940, Landsteiner and Weinn discovered the Rh blood group system. The gene for the Rhesus antigen (D or Rho) of the Rh blood group is located on chromosome 1.

There are three closely linked gene loci which produce the Rh system—C, D and E and their allele's c, d, and e. These genes give rise to the red cell antigens C, D, E c, d and e.

Of these the type D antigen is widely prevalent in the population (85 %) and is also considerably more antigenic than the other Rh - antigens. Therefore anyone who has this type of antigen is said to be Rh - positive whereas persons who do not have D – antigen are said to be Rh - negative. In our population about 85 percent is Rh+ve and 15 percent is Rh-ve.

Unlike the ABO blood group system, the Rh antibody is not naturally occurring. This means that an anti Rh antibody will not occur in the plasma of an Rh-ve person unless, he or she is challenged by the Rh antigen, e.g. by transfusion or transplacental passage of Rh+ve red cells.

Anti Rh antibodies are IgG type incomplete antibodies requiring Coombs reagent to produce agglutination (antiglobulin test).

Other Blood Group Antigens

In addition to the ABO and RhD antigens, hundreds of other RBC blood groups have been discovered and several are well known to the blood bank for their hemolysis causing antibodies. These clinically significant blood groups include the Kell (K), Duffy (fy), Kidd (JK), MNS_S and other blood group systems. These antigens are much less immunogenic than the RhD antigen but the antibodies are seen frequently enough to be of concern for safe transfusion.

Antibody Screening

This involves testing of the patient's serum for the presence of any Kell, Duffy, Kidd or other minor blood group antibodies which will cause significant agglutination.

Cross-Matching of Blood (Compatibility Testing)

Cross matching or compatibility testing consists of excluding *in vitro* antibody activity against donor cells which if given would provoke a transfusion reaction.

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Having chosen blood of the same ABO and Rh groups as the recipient the donor's red cells must be tested against the recipient's serum. The donor's serum is much less important because any antibodies it may contain should be so diluted by the recipient's plasma as to become insignificant.

How It is Done?

This is done by adding serum in 2:1 ratio to 3 percent donor cells suspended in normal saline; the mixture is then incubated at 37°C for 45 min. following which it is examined for agglutination or even hemolysis which indicates incompatibility.

No single procedure detects all clinically important antibodies but as a minimum, the indirect antiglobulin test should always be performed if possible. In this the antiglobulin reagent (of animal or monoclonal origin) is added to cells which have been incubated as above. Any cells coated with patient's antibody will then agglutinate, again indicating incompatibility.

HAZARDS OR COMPLICATIONS OF BLOOD TRANSFUSION

- Immunological complications.
- Infections complications
- Miscellaneous, e.g. congestive cardiac failure, air embolism, coagulation defects, complications due to massive transfusion (see above).

Immunological Complications

The immunologically mediated reactions may be directed against red or white blood cells, platelets or plasma antigens (of Donor's blood), e.g. IgA.

Reactions Due to Red Blood Cells

Immediate Hemolytic Transfusion Reactions (HTR)

Most reported deaths from transfusion reactions result from ABO incompatible transfusion. Most have occurred when a person with type O blood received type A RBCs because of a clerical error in identification at the time the blood sample was drawn, during laboratory processing or when the unit was administered.

- 5 to 10 ml of blood is sufficient to cause reaction.
- Mechanism — Anti A or Anti B antibodies (IgG or IgM both of which fix complement) in the recipient will attach to donor red cells, activate complement and cause complement mediated destruction of the RBCs (Type II hypersensitivity).
- Clinical features—The conscious patient may become aware immediately that something is wrong. The patient develops a rigor, fever and pain in the loins. In patients under general anesthesia, there will be excess local oozing at the site of operation and hypotension.
- Preventive measures:
  i. Accurate grouping and cross matching.
  ii. Accurate collection and storage under strict aseptic conditions.
  iii. Blood should not be vigorously shaken or heated.
  iv. The date of expiry should be duly noted before transfusion. Any evidence of hemolysis should be looked for.
- Treatment
  i. Immediate stoppage of transfusion and a fresh specimen of venous blood and urine from the patient is sent together with the residue of all the used units of donor blood to the laboratory for checking.
  ii. Catheterization to record the urine output and a close watch of the patients pulse and B.P.
  iii. Fursemide 80 to 120 mg is given to provoke a diuresis and repeated if the urine output falls below 30 ml per hour. Dialysis may be necessary.
  iv. Antihistamines and hydrocortisone often gives beneficial results.

Delayed Hemolytic Transfusion Reactions

Typically occurs 5 to 10 days after transfusion. Cause: Titers of antibodies in the patient may have been below the sensitivity of an antibody screen or major cross match. When the patient is transfused, reexposure of the antigen, to the patient's memory cells causes, renewed synthesis of antibody which may take a few hours to a few weeks to develop. Common antibodies include Kidd and Rh. This reaction is most common in patients who have become sensitized through transfusion or pregnancy.

It is suspected when jaundice appears some days after transfusion or when the hemoglobin concentration fails to rise by the expected amount or drops unexpectedly.

Incompatible White Cells

- Simple febrile reactions which occur either during or shortly after a transfusion.
- Most often they are due to the presence of recipient's white cell antibodies complexing with donor leukocytes and causing the release of pyrogens from the monocytes and granulocytes. The white cell antibodies in the recipient are formed as a result of previous transfusions or pregnancies.
- Febrile reactions may be quite severe but usually last only a few hours. If they are troublesome in patients requiring further transfusions, leukocyte depleted blood may be given.
- Most reactions respond, however to slowing the transfusion and giving aspirin or paracetamol.

Transfusion related acute lung injury (TRALI) or transfusion associated ARDS.

It occurs as a result of incompatibility between donor antibodies and recipient granulocytes. Signs and Symptoms occur within 6 hours—fever, dyspnea and non cardiogenic pulmonary edema, PCWP < 18 mm Hg.

Treatment—O_2, PEEP, fursemide and Dopamine, recovery usually occurs within 24 to 48 hours. (PEEP – Positive end expiratory pressure)

Incompatible Platelets

Post-transfusion purpura may occur in patients who have been previously sensitized to a foreign platelet antigen. On subsequent exposure they mount a secondary response, which causes destruction of the patients own platelets.

Adverse Reactions of Plasma

a. Urticaria results from the allergic reaction to plasma products in the donor blood. Here the patient's IgE antibody complexes with a protein present in the donor's plasma. It is treated by stopping

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the transfusion and giving an antihistaminic drug (Chlorpheniramine 10 mg).

b. Severe anaphylactic reaction can occur due to anti-IgA formed as a result of previous transfusion in subjects who either lack IgA or who belong to a different IgA subclass.

Infectious Complications

The following infections can be transmitted by blood transfusion

a. Viral—Hepatitis B, Hepatitis C and Hepatitis D, HIV, cytomegalovirus (CMV) and Epstein – Barr virus.
b. Bacterial—Syphilis, brucellosis.
c. Protozoal—Malaria, Chagas disease.

Hepatitis B: All donors are routinely screened for Hbs Ag. All patients requiring multiple transfusions and all health care workers should be vaccinated against hepatitis B.

Hepatitis C: Majority of cases are seen as post-transfusion hepatitis. 50 percent of infected patients develop chronic hepatitis and 10 percent of patients, cirrhosis or hepatoma.

Hepatitis D: The virus uses HbsAg as its coat and cannot exist without HbsAg. This is fortunate because screening for HbsAg is all that is required to exclude the virus.

HIV: Can be transmitted by cellular elements and plasma.

CMV: Susceptible groups include immature neonates, immunosuppressed patients and pregnant mothers seronegative for CMV. In these patients, blood must be filtered to remove the leukocytes which transmit the intracellular virus.

Malaria: In areas where malaria is endemic, a course of antiprotozoal therapy is usually prescribed along with the transfusion. In non-endemic areas, travelers, who have recently resided in an endemic area, are excluded from donation.

Miscellaneous Complications

1. *Congestive cardiac failure*—This can occur if blood is transfused too rapidly especially in the elderly or when there is cardiovascular insufficiency. If blood has to be transfused in a case of anemia, it is better to give packed red cells. At the same time, the transfusion should be given slowly over a period of many hours.
2. *Air embolism*— Air may be sucked into an open vein at the end of the transfusion. If a drip chamber is used which contains a plastic float, that plugs the exit when the fluid falls to a low level this complication is prevented. Collapsible bags for blood and IV fluids are also relatively safe, unless they have been punctured by a needle for adding some drug to the infusate.
3. *Coagulation defects*— These may arise as follows:
   i. Stored blood is low in platelets, factor V and VIII. Therefore, if large volumes of stored blood are used, these factors may get diluted and hemorrhage can occur.
   ii. Disseminated intravascular coagulation (DIC)—This commonly follows ABO incompatibility, when coagulation takes place in the blood vessels, the various coagulation factors namely fibrinogen, factor II, V, VIII and platelets get used up, so that hemorrhage results. For the treatment of DIC, these factors have to be replaced.

AUTOLOGOUS TRANSFUSION

This means transfusion of patients own blood. It acts as an alternative to homologous transfusion with the advantages in safety and cost.

It may be given in the following forms:

a. Preoperative autologous deposit.
b. Preoperative isovolemic hemodilution and
c. Peroperative blood salvage.

Preoperative Autologous Deposit (PAD)

Donation criteria consists of

- Hemoglobin > 10 gm/dl.
- Active infection is a contraindication
- Donation is ill advised in presence of severe cardiorespiratory disease, e.g. recent myocardial infarction, angina, left main coronary artery stenosis, etc.

The minimum accepted Hb level for surgery is 9 gm/dl. A unit is taken each week and 500 ml of saline is infused to maintain the intravascular volume and 200mg of ferrous sulfate per day, started. Two to four units of blood are predeposited in this way, the final donation being made not less than 72 hours prior to surgery. Blood is screened for HIV, Hepatitis and syphilis and grouped, "Cross over" for use on other patients is prohibited.

Preoperative Isovolemic Hemodilution

For some operations like cardiopulmonary bypass 1 to 2 units of blood may be withdrawn, just before surgery. The amount is replaced with crystalloids or colloids. Blood is infused postoperatively. This procedure not only restores much of the individuals red cells but also provides platelets.

Peroperative Blood Salvage

Blood is collected from the operation site, filtered to remove the cellular debris, activated clotting factors, etc. by a cell salvage machine and then reinfused to the patient during the operation.

It is contraindicated in presence of sepsis or malignancy.

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