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Руководство к практическим занятиям по общей хирургии (на английском языке)

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The manual

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CHAPTER V

BLOOD TRANSFUSION

Transfusiology **(Latin *trans*-, across + *fundere*, to pour, Greek *logos*-,word, thought) is part of clinical medicine which deals with transfusion of blood, its components and substitutes to achieve therapeutic effect through their actions on the composition of blood and fluids of the human body.**

PRODUCTS USED FOR BLOOD TRANSFUSION

In clinical practice, whole blood, its components and products may be used.

Whole blood. Certain precautions are necessary in checking donor and blood for transfusion. No donor should be used who has a haemoglobin value below 12 g/l or who has a history of syphilis, malaria, viral hepatitis, chronic allergy, drug sensitivity or HIV infection. The donor's serologic test for syphilis and the test for anti- HBsAg and HIV antibodies should be negative. Do Rh typing on both donor and recipient and check recipient's serum for unusual antigens. Cross-match blood. Blood for transfusion is drawn into containers with ACD (acid-citrate-dextrose), CDP (citrate-dextrose-phosphate), or CDPA-1 (citrate-dextrose-phosphate-adenine) anticoagulant (1:4), which binds calcium ions, prevents blood from coagulating and thus markedly prolongs the viability of red blood cells. Salts of EDTA and heparin may also be used as anticoagulants. Apart from the anticoagulant, the product contains antibiotics and glucose.

The blood must be stored at 4–6 °C. Properly stored blood may be used for transfusion until 21 days (with ACD) or 35 days (with CDPA) after withdrawal from the donor. Blood should not be used after the expire date.

It is noteworthy that not all the functions of the preserved blood are equally maintained. The most vulnerable are the haemostatic factors and immunity, whereas the oxygen-binding ability remains operable for a longer period. Therefore, when bleeding arrest is required, it is recommended that the blood be obtained at least 2–3 days prior to transfusion, and for the purpose of immune correction at least 5–7 days.

Freshly citrated blood. 6% sodium citrate is used as anticoagulant in the ratio of 1:10. Such blood should be used immediately or within some a few hours after withdrawal.

Heparinised blood. It is used to fill in the artificial circulation machine. This requires large amounts of blood that is why citrated blood is dangerous as it may result in citrate intoxication. Heparin, glucose and chloramphenicol are used as the preservative. Heparinised blood can be stored at 4 °C for only 24 hours.

Blood components. Components of blood have been widely used due to the significant incidence of complications associated with the transfusion of whole blood. Moreover, the therapeutic effect of blood component transfusion is higher since it acts directly on specific bodily functions. This type of transfusion is indicated in chronic anaemia and bleeding (packed red blood cells); in leucopenia and particularly in agranulocytosis and immune deficiency (granulocyte concentrates); in thrombocytopenia (platelet concentrates); in hypo- or dysproteinaemia, coagulation disorders, deficient blood circulatory volume (liquid, frozen or dried plasma, albumin, protein). In addition, component transfusion is cost-effective, i.e. higher therapeutic effect is achieved with lesser amounts of blood products.

Red blood cell products are obtained from whole blood, which is either left to stand or centrifuged for separation of plasma. They differ from donated blood in the minimal content of plasma and high concentration of red blood cells (haematocrit 0,65–0,8 l/l); they are stored in bottles or plastic bags at 4–6 °C for 21 days.

Packed red cells. Sodium citrate is used as the preservative. These are stored at 4–6 °C for 8–15 days and indicated for bleeding, anaemia and other blood diseases, and sepsis.

Washed and frozen red blood cells are the preparations of red cells suspended in saline, produced by for three to five-fold cell separation.

Freezing can be done either gradually (in electro-freezers at –70–80 °C) or rapidly (using liquid nitrogen at -196 °C). *Frozen* red blood cells can be stored for 8–10 years. To thaw the red blood cells, the container is put into water bath heated to as high as 45 °C and is then washed. Red blood cells can be stored at 4 °C for maximum one day after thawing.

The advantage of frozen red blood cells is that they contain minimum, if at all, undesirable antigens (free haemoglobin, leucocytes, platelets), clotting factors, potassium, serotonin. These are, therefore, indicated for allergies, post-transfusion

reactions, cardiac or renal insufficiency, thrombosis and embolism. The blood of a universal donor can be used to avoid massive transfusion syndrome. Washed native or frozen red blood cells are used for patients with HLA incompatibility or those sensitised to plasma proteins.

Platelet concentrates are prepared either from whole donated blood by centrifugation or by plateletpheresis of single donors' blood using cell separators. They may be stored at 4–22 °C for up to 7–9 days; it is, however, advisable to use them freshly prepared within 24 hours. The indications include bleeding in patients with thrombocytopenia of different origin (blood disorders, post-radiation conditions, chemotherapy, as well as haemorrhage resulting from massive transfusions for profuse bleeding, disseminated intravascular coagulopathy). Transfusing platelet concentrates one has to take into account the ABO and Rh system compatibility, and to perform the biological testing since the platelet products may contain residuals of donor's red blood cells.

Granulocyte concentrates are preparations comprising mainly leucocytes with traces of red blood cells, platelets and plasma. These are usually collected from HLA-matched donors by cell separation, or leucopheresis, and stored in bottles or plastic bags at 4–6 °C for maximum 24 hours. Again, transfusing white blood cells the physician will take into consideration the ABO, Rh system compatibility. It is a must to perform the biological test for compatibility. The granulocyte concentrates are used for patients with neutropenia, particularly in agranulocytosis resulting from radiation, chemotherapy, and severe sepsis. Post-transfusion reactions involve dyspnoea, rigors, fever, tachycardia and hypotension.

Blood plasma is obtained by means of separation of blood. It contains protein and other essential components (enzymes, vitamins, hormones, antibodies). Liquid plasma should be used ex tempore, within 2–3 hours after its collection; plasma is collected into 50–250 ml bottles or plastic bags. It may also be used previously *frozen* or *dried* (lyophilised). *Frozen* plasma should be stored for 90 days at -25 °C or for 30 days at 10 °C. Before use it has to be thawed at 37–38 °C. Any suspensions, a change in colour (e.g. greyish-red discolouration), unpleasant smell or evidence of turbidity found before transfusion all preclude its application.

Plasma is indicated for replacement of blood circulating volume (massive whole blood loss, i.e. blood loss exceeding 25% of blood volume, in combination with whole blood and red cell products), bleeding arrest (in haemophilia) and parenteral nutrition (in burns, sepsis). It is contraindicated for severe allergies.

The usual dose is 100–500 ml or even 500–1,000 ml in shock. Group compatibility (ABO) of the donor and recipient is taken into account and biological testing performed.

Dry plasma is available in 100, 250 or 500 ml bottles and stored for 5 years. Prior to its use it will be dissolved in distilled water or normal saline. Indications for use are similar to those of liquid and frozen plasma, except that dry plasma is ineffective if used for bleeding control. Biological test is a prerequisite.

Albumin. It is prepared through separating plasma and subsequent pasteurising and contains 5, 10 or 20 g of protein (97% albumin) in a 100 ml solution. Its 5, 10 and 20% solutions are available in 50, 100, 250 or 500 ml bottles. A high oncotic activity accounts for its ability to keep water within the body and hence increase the circulating blood volume.

It is therefore indicated for shock of whatever origin, burns, hypoproteinaemia in oncological patients, debilitating and chronic infections, as well as plasmopheresis.

Combined with blood transfusion and red blood cell products, albumin works more efficiently in blood loss and post-haemorrhagic anaemia. Transfusion of albumin is indicated for hypoalbuminaemia, with the level of albumin being 25g/l. The dosage of the preparation is as follows: 300–500 ml (5%); 200–300 ml (10%); 100–200 ml (20%) and the like. The usual rate of its infusion is 40–60 drops/minute while in shock it may be given in bolus. Biological testing helps prevent anaphylaxis, which, if severe, is a relative contraindication for transfusion of albumin.

Protein is prepared either from plasma or blood serum. It consists of albumin (75–80%) and a and b globulins (20–25%). The product usually contains 40–50 g/l of protein. Therapeutically, protein is similar to plasma. Pasteurised, i.e. free of hepatitis viruses, protein is available in 250–500 ml bottles. The daily dose for patients with hypoproteinaemia is 250–500 ml of the solution. The preparation is given for several days. For severe shock and massive blood loss the dose is increased to as high as 1,500 – 2,000 ml. It is mandatory to give protein with either donated blood or red cell products. The rate of its infusion depends on the patient's condition: usually infused slowly it is given in bolus for shock and hypotension.

Cryoprecipitate is obtained by allowing the frozen plasma from a single donation to thaw at 4–8 °C and removing supernatant. It is stored at 0 °C in 15 ml vial. Cryoprecipitate contains factor VIII:C, or antihaemophilic globulin, factor XII, or fibrin-stabilizing, or von Willebrand factor (vWF), and fibrinogen. The preparation is indicated for patients

with defective blood coagulation secondary to a decrease in VIII factor levels (haemophilia A and Willebrand's disease).

Prothrombin complex is prepared from blood plasma and distinguished by high concentrations of factors II, VII, IX, and X. The preparation is administered to arrest or prevent bleeding in patients with haemophilia B, hypoproteinaemia, and hypoproconvertinaemia.

Fibrinogen is obtained from plasma. Its preparations are indicated for congenital and acquired hypo- or afibrinoginaemia, as well as intractable bleeding.

Prepared from plasma, *thrombin* contains thrombin, thromboplastin and calcium chloride, and is stored in vials in powdered form. It is used for capillary and parenchymal bleeding, and extensive wounds.

Apart from the above-mentioned preparations, immunologically active preparations are also prepared from the donated blood - g globulin (staphylococcal, tetanus and varicella immune globulins).

Complex immune preparations (e.g. sandobulin) are obtained from plasma donated by people who have had the disease and therefore acquired the immunity, and those vaccinated against the disease. The preparations contain high titres of antibodies. These are stored in vials and given either intramuscularly or intravenously as indicated.

BLOOD GROUPING

The antigen components of human blood are numerous. To date, about 500 cellular antigens that are the components of blood, as well as above 40 combinations of antigen systems have been identified. In practical transfusiology, the ABO and Rhesus factor (Rh) systems are regarded as the most important.

I. With standard isohaemagglutination serum

For the blood grouping the following are required:

- two sets of standard sera I (0), II (A), III (B) of different serial groups;
- an ampoule of serum IV (AB) (Put a dry clean pipette into each ampoule that contains the serum!);
- a vial with normal saline and a pipette;
- a clean dry plate;
- a ground slide;
- sterile spear-like needles for finger pricks;
- sterile swabs;
- alcohol.

The procedure has to be performed in a well-lit room at 15–25 °C.

Each vial of the standard serum has to be labelled with information of the blood group, serial number, titre, expiry date, and the manufacturer. Never use vials without the relevant information provided.

A standard serum ampoule for blood (ABO system) grouping is normally supplied with a specific colour indicator: I (0) – colourless (no stripes on the label), II (A) – blue (two stripes on the label), III (B) – red (three stripes on the label), IV (AB) – yellow (four stripes on the label). The ampoule with serum is kept at 4...10 °C, the sera being clear. The ampoule should be intact.

Never use for transfusion the serum that contains flakes, sediments or turbidity. The typing serum should be potent, with a titre of at least 1:32 and the first signs of agglutination being evident within 30 seconds. Expired serum may never be used.

Procedure. Divide the plate into 4 parts with a colour pencil and label the parts clockwise – I (0), II (A), III (B). Place the serum of the two series of groups I (0), II (A), III (B) on the corresponding areas using their individual pipettes. Cleanse the finger with alcohol and prick it with a sterile needle. Clear away the first blood drop with a swab, while further drops of blood are to be placed with different edges of the slide and thoroughly mixed with a drop of serum (the drop of blood should be 5–10 times as smaller as that of serum). Shaking the plate facilitates mixing the serum and blood. Check initial results in 3 minutes, then add a few drops of normal saline, and shake the plates again to mix the drops again. Examine finally the mixture for agglutination in 5 minutes (fig. 33, colour inset).

In a positive isohaemagglutination reaction, flakes and granulations of red blood cells that have clung together do not separate on dilution with normal saline or shaking. In a negative reaction, drops of serum on the plate, alternatively, appear transparent, evenly coloured pink, with no granules or flakes visible. The four patterns of the agglutination reaction with standard sera of groups I (0), II (A), III (B) are possible:

1. The agglutination reaction is negative with the three sera in both series. The blood under examination is of *group I (0)*.

2. The isohaemaglutination reaction is negative with test serum II (A) in both series and positive with groups I (0) and III (B). The blood under examination is of *group II (A)*.

3. The isohaemaglutination reaction is negative with test serum III (B) in both series and positive with I (0) and II (A) groups. The blood under examination is of *group III (B)*.

4. All the serum of I (0), II (A), III (B) groups give positive reactions to both series of serum. The blood under examination is of *group IV (AB)*.

However, before making the final conclusion another investigation has to be performed with group

IV (AB) test serum, following the same procedure as mentioned above. A negative isohaemaglutination reaction following this test attests the blood being of group IV (AB).

If other types of reactions are encountered it means that the procedure was followed improperly.

The information as to the patient's blood group is noted in his/her folder or case history, as well as on the front page of the file with the date and signature of the physician who has conducted the examination.

Mistakes in blood grouping tests are possible when the reaction of agglutination, though having actually occurred, cannot be identified and vice versa.

Agglutination can be overlooked in the following situations:

1) if the strength of the test serum is mild or the red cells are of low agglutinative power;

2) if an excessive amount of blood has been added to the test serum;

3) if the temperature of the room in which the reaction is being performed is too high, a condition which slows down the reaction of agglutination.

To prevent the errors, the test serum to be used should be active in high titres, the ratio of blood to serum being 1:5–1:10. The temperature should not exceed 25 °C and the results should be noted in as late as 5 minutes from the beginning of the test.

Agglutination can be erroneously identified due to drying up the serum drop, the arrangement of the red cells into coin-like piles or «cold» agglutination if the test is performed at room temperature below 15 °C. The addition of normal saline to the blood serum drop and performing the test at a temperature above 15 °C eliminates the possibility of such errors. In general, errors in blood grouping almost always result from not following the instructions have not been followed correctly.

In all dubious cases repeat the test using test serum of different series and or new standard red blood cells.

II. With anti A and anti B monoclonal antibodies, or anti A and anti B celiclones

Anti A and anti B celiclones are used for ABO blood grouping as an alternative to the standard isohaemaglutination serum by way of detecting antigens A and B in the red blood cells by the antibodies contained in celiclones. «Celiclone» is a diluted ascitic fluid of mice carriers of hybridomas that are producing of IgM against antigens A or B. As distinct from the standard ABO-serum, a celiclone provides a quicker and more pronounced reaction of agglutination. The use of celiclone eliminates the risk of transmission of hepatitis B or C viruses or HIV.

The grouping should be performed at 15–25 °C.

Procedure

- Place big drops of anti–A and anti–B celiclones on a labelled plate or a flat plastic surface.
- Put the drops of blood in question (which should be one-tenth as big in size nearby and mix using different sticks or different edges of the ground slide for each group).
- Shake the plate slightly and observe for about 2,5 minutes (the reaction normally occurs within 3–5 seconds to form small red aggregates followed by flakes).

The following patterns of the reaction are possible:

1. *Negative* agglutination with both anti A and anti B celiclones suggests that blood contains neither A- nor B-agglutinogens and thus the patient's blood is of group I (0) (fig. 34, colour inset).

2. *Positive* agglutination with anti A celiclones indicative of A agglutinogens contained in the patient's red blood cells. The blood is therefore of group II (A).

3. *Positive* agglutination with anti B celiclones. The red cells of the blood under examination contain B agglutinogens and are consequently of group III (B).

4. *Positive* agglutination with both anti A and anti B celiclones. The patient's red blood cells contain A and B agglutinogens, which is suggestive of group IV (AB) blood (tab. 2).

Table 2. Agglutination reaction of tested red blood with celiclones anti-A and anti-B

Agglutination reaction		Tested blood group
celiclone anti-A	celiclone anti-B	
–	–	I (0)
+	–	II (A)
–	+	III (B)
+	+	IV (AB)

If the reaction is positive with both anti A and anti B celiclones, i.e. the blood is supposed to be of group IV (AB), a further test should be performed using normal saline, to eliminate the possibility of non-specific agglutination. A big drop (0,1 ml) of normal saline is mixed with a smaller one (0,001 ml) of the test blood. The absence of agglutination supports the conclusion that the blood is of group IV (AB).

Liquid anti A and anti B celiclones are stored in ampoules or vials, labelled red for anti A and blue for anti B celiclones. They are to be kept in the refrigerator at 2–8 °C for two years.

Otherwise, agglutinative grouping is performed by using washed standard red blood cells.

III. With the standard washed red blood cells of the known group

Procedure. Place three to four millilitres of the patient's venous blood into a glass tube and centri-

fuge it. Put a few drops of the serum on a labelled plate accordingly and add a few drops of the standard red blood cells, one-fifth as big as those of the serum under investigation, mix these using the edges of a slide, and shake the plate for 3 minutes. Then mix one drop of normal saline with each portion and keep shaking the plate for some more time. Observe the reaction after 5 minutes. The four patterns of the reactions are possible:

1. *A negative* reaction with group I (0) red blood cells but a positive one with those of groups II (A) and III (B) imply the patient's blood being of group l (0).

2. *A negative* reaction with group I (0) and II (A) red blood cells but a positive one with those of group III (B) are indicative of the test blood being of group II (A).

3. *A negative* reaction with group I (0) and III (B) red blood cells but a positive one with those of group II (A) suggests that the blood under investigation is of group III (B).

4. *A negative* reaction with group I (0), II (A) and III (B) red blood cells signifies group IV (AB) blood.

Rhesus factor (Rh) typing

Based on conglutination, Rh typing is performed with special anti-rhesus serum at the laboratory. ABO grouping usually precedes this.

The equipment and prerequisites are as follows:

1. Two different series of the standard anti-Rh serum to match the group of the blood under investigation (you may also use a compatible group of the standard washed Rh positive and Rh negative red blood cells of the same group instead).
2. Petri dish.
3. Water bath.
4. Pipette for serum.
5. Ground slide (or glass rod).

Procedure

- Put three big drops of the anti-Rh serum of one serial type into the Petri dish;
- add three drops of that of the other series to arrange the drops in two parallel lines;
- place a few small drops of the test blood on the anti Rh drops in the first vertical row of both; series (in the ratio of serum to blood as 10:1 or 5:1);
- put the same small amount of standard Rh positive red blood cells on the serum drops in the second vertical row (to check for its strength);
- add the drops of Rh negative standard red blood cells to the serum drops in the third row (to check for its specificity);
- mix the serum and red blood cells of each row separately, with different glass rods, cover the dish and place it on the water bath at 46–48 °C;
- observe the results in 10 minutes (the room should be well lit).

Results

1. The drop with the standard Rh-positive red blood cells should give a positive reaction of agglutination.

2. The drop with Rh-negative red cells should be negative.

3. The agglutination seen with the drops in both series of the serum with red cells of the blood under examination suggests the presence of Rh factor in the blood is rhesus positive.

4. Otherwise it is Rh-negative.

It will be noted that the addition of normal saline to the serum, as is the case with ABO grouping, must be avoided, since it may counteract agglutination.

The factors that may be responsible for the mistakes in Rh typing are as follows:

- reduced activity of the standard Rh serum;
- wrong serum-blood proportions;
- inappropriate room temperature;
- reduced exposition period (less than 10 minutes);
- addition of normal saline into the serum;
- absence of testing for controls for serum strength and specificity;
- group incompatibility of the standard serum with the blood under investigation and the standard red blood cells.

In emergency, Rh typing can be performed at bedside. An «express» method of Rh typing requires special reagents – anti-Rh serum of group IV (AB) diluted in 20–30% albumin used as the conglutin, i.e. that substance that allows aggregation of red blood cells under room temperature.

Procedure

- Put a drop of the anti-Rh serum of group IV (AB) and nearly a drop of Rh-negative serum of group IV (AB) free of antibodies on a ground slide or a Petri dish;
- add to each drop of serum 2–3 times less than the patient's blood in the amounts half even less as much as those of the serum;
- mix these with a glass rod or by shaking for 3–4 minutes;
- add one drop of normal saline to each mixture;
- Observe the results in 5 minutes.

Results

1. Agglutination of the red blood cells present with the anti Rh serum and absent with the control serum implies Rh-positive blood.

2. The absence of agglutination with the serum is indicative of the patient's blood being Rh-negative.

3. In case of agglutination with both sera the reaction has to be regarded as unclear.

In emergency, transfusion of only Rh-negative blood is possible, and if it is not available and the patient's condition requires blood transfusion, Rh-positive blood may be given following cross-matching the blood for Rh compatibility.

The importance of blood grouping during blood transfusions

The antigens of blood, mainly those of ABO system and Rh, can be responsible for its immunological incompatibility. If the recipient's (i.e. patient's) blood contains antigens against to those of the red blood cells and antibodies in donor's plasma, agglutination of the red blood cells is likely to occur. This type of agglutination can be seen when similar antigens and antibodies A and б, B and в, as well as Rh antigens and anti Rh antibodies react. For this to take place there should be sufficient amounts of antibodies, or the titre, present in the blood serum. Ottenberg's rule is based on this principle, which says that the donor's red blood cells transfused agglutinates and since the agglutinin of the transfused blood is diluted by the recipient's blood, the concentrations are not as high as to cause agglutination of the recipient's blood. Without cross-matching all recipients may therefore receive only group I (0) blood, as this blood is devoid of any agglutinogens (the holders of group I blood are referred to as *universal donors*). On the other hand, patients of group IV (AB) blood can receive that from donors of all the other blood groups, since the patient's blood is free of any agglutinins (the holders of group IV blood are called *universal recipients*). However, if large amounts of blood are needed, as is the case in uncontrolled bleeding, agglutinins of the blood transfused can cause agglutination of the patient's red blood cells. Ottenberg's rule is applicable only when the amount of blood to be transfused does not exceed 500 ml.

If Rh-positive blood is transfused for the first time to a Rh-negative patient who has not been sensitised earlier, overt incompatibility reactions are not observed, antibodies, however, being formed. Giving blood to an Rh-negative woman who has been sensitised through pregnancies with a Rh-positive foetus may result in Rh incompatibility. Transfusing Rh-negative blood to a Rh-positive recipient, one should bear in mind that production of antibodies to the weak antigen system of Rh present in the transfused blood cannot be ruled out.

According to the current principles of transfusiology, the blood transfused may be of only the same group (the ABO system and Rh group). In emergency, Ottenberg's rule can be applied.

METHODS OF BLOOD TRANSFUSION

The following methods of blood transfusion are used:

1) indirect blood transfusion (transfusion of preserved blood);
2) direct blood transfusion;
3) exchange blood transfusion;
4) autologous blood transfusion.

In clinical practice indirect transfusion is the commonest method which involves transfusing preserved blood or blood components.

Direct blood transfusion

Nowadays, transfusing blood directly from a donor to the recipient is rarely done. The indications for direct blood transfusion are as follows:

- intractable bleeding in a patient with haemophilia;
- haemostatic disorders (acute fibrinolysis, thrombocytopenia, and afibrinoginaemia); following massive blood transfusions; blood diseases;
- degree III traumatic shock with concurrent blood loss of at least 25–50% of the circulating blood volume and unresponsiveness to transfusion of preserved blood.

The donor for direct blood transfusion should be examined at a blood transfusion station. The ABO and Rh typing of both the recipient and donor and cross-matching are performed immediately prior to the transfusion, while biological testing should be done at the beginning of transfusion.

The procedure is performed by a physician or nurse. Have the donor lie on a stretcher at the patient's bedside or the operating table. Place the table with instruments covered with sterile materials in between the bed and the stretcher. Put on the table twenty or thirty 20 ml syringes with needles for venipuncture with rubber tubes, sterile gauze packs and sterile clamps (Bilroth's type). Before the transfusion, the patient is given normal saline intravenously. The nurse collects a small amount of blood into a syringe, presses on the rubber tube and hands it over to the physician who will inject it into the patient's vein. Meanwhile, the nurse should fill in another syringe (fig. 35). The manipulation is done synchronically. Put 2 ml of 4% sodium citrate in each of the first three syringes before transfusion to prevent blood clotting, these initial blood transfusions are performed slowly (one syringe for each 2 minutes). This serves as biological testing.

A special apparatus with a roller pump can also be used. The apparatus is used according to the instructions attached. Biological test is done by rapid transfusion of 20–25 ml of blood with a three-fold

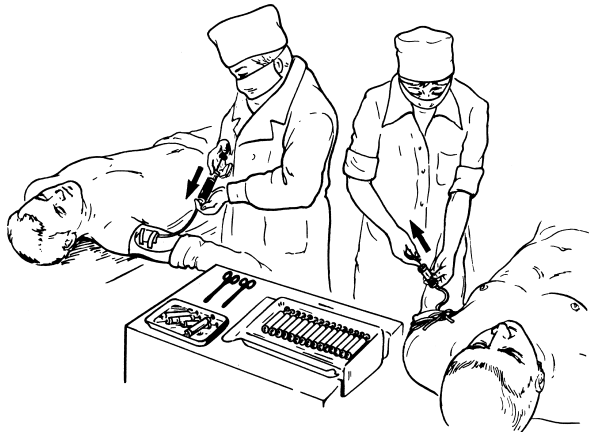

Fig. 35. Direct blood transfusion using syringes.

reduction after each portion transfused. The apparatus provides the rate of transfusion as high as 50–75 ml/minute.

Exchange blood transfusion

This method involves a partial or full drainage of the patient's blood and its replacement with the equivalent volume. Exchange blood transfusion is indicated for poisoning, haemolytic disease of the newborn, immediate haemolytic transfusion reaction, and acute renal failure. Blood contaminated with toxic compounds is removed and infusion is aimed at replacing the blood volume.

In exchange blood transfusion it is important to use either freshly prepared blood or that has not been stored for too long for. Blood infusion is done into any of the superficial veins while exfusion (draining out) is performed through a major vein or artery to prevent clotting. Both drainage of the patient's blood and infusion of donor's blood are to be done simultaneously at a rate of 1 l per 15–20 minutes. To complete blood exchange 10–15 l of donor's blood are needed.

Autologous blood transfusion

This involves transfusion of the patient's own blood that has been obtained either long before surgery, immediately before or during surgery. Autologous blood transfusion is void of all disadvantages that transfusion of donor's blood may have, such as immunisation of the recipient, development of homological blood syndrome, and, apart from these, it eliminates the problem of finding individual donors for patients with antibodies to red blood cell antigens that are not included in the ABO and Rh systems.

The *indications* for autologous blood transfusion are as follows:

1) rare blood group of the patient;
2) inability to find a donor;
3) increased risk of a post-transfusion reaction;
4) impending operation associated with a massive blood loss.

Autologous transfusion is *contraindicated* in

1) infections;
2) severe liver or kidney diseases;
3) debilitating malady (e.g. full-blown tumours).

The widely known method is *blood salvage*, or retransfusion of the blood lost and collected during or after surgery. It is applied in such abdominal conditions as ectopic gestation, rupture of the spleen, liver or mesenteric vessels; in closed damage to the chest organs – injuries to the intrathoracic vessels and the lung. Reinfusion is effectively used for blood replacement during operations when the patient's blood from the wound is collected and reinfused. Blood collected into a bottle with anticoagulant is filtered through 8-layer gauze and emptied into the transfusion system equipped with a standard microfilter for onward blood transfusion. Blood salvage is contraindicated if there is a damage to any hollow organ of the chest (the major bronchi, oesophagus) and the abdominal cavity (the stomach, intestine, gallbladder, extra-hepatic bile ducts, and urinary bladder) as well as in malignant tumours. Also, retransfusion of the blood that has stayed in the abdominal cavity for more than 24 hours should be avoided. Reinfusion is contraindicated when the accumulated blood is contaminated with pus, stomach and intestinal contents, bleeding from a ruptured uterus and malignant tumours.

To preserve the blood, preservative solutions in their ratio to blood of 1:4, or most often heparin solution is used – 10 mg of heparin in 50 mL of normal saline is mixed with 500 ml of blood. The accumulated blood is collected by scooping dry with a small metallic cup and immediately filtered through an 8-layer gauze. Collecting blood by a suction machine with a pressure of at least 0,2 atmospheres is more effective. Blood collected into a bottle with anticoagulant is filtered through 8-layer gauze and emptied into the transfusion system equipped with a standard filter for onward blood transfusion.

Autotransfusion, using previously preserved blood, is done by draining the patient about 4–6 days before scheduled surgery and storing the blood for later use. Four to six days is enough for the patient to regain their lost blood, the stored blood being intact with all the valuable components. The process of recovery after the donation is facilitated by not only the transfer of interstitial fluid into the blood stream (like is the case in any blood loss), but also by the stimulatory effect of blood drainage on haemopoiesis. Preparing blood through that way yields a volume of as great as 500 ml. When blood is collected in steps within a long-term preoperative period, as much as 1,000 ml can be preserved within 15 days or even 1,500 ml within 25 days. If this method is to be used, the blood volume of 300–

400 ml first is drained, it is then reinfused every 4–5 days and 200–250 ml more than what has been given are drained. Such method provides a large amount of good quality blood that can be stored for maximum 4–5 days.

Blood is collected into bottles with preservatives and stored at 4 °C. To be able to keep blood for a long time it has to be frozen at -196 °C.

Haemodilution is another method of autologous blood transfusion. Urgent preoperative haemodilution is done immediately prior to the surgery and is aimed at reducing bleeding during the intervention. As a result, the patient loses the diluted blood (with limited amounts of blood cells and plasma factors); and replacement of blood loss by auto-blood follows. Immediately prior to operation the patient's blood is drawn into a bottle containing some preservative and at the same time the haemodilution solution consisting of rheopolyglukin, 20% albumin and Ringer–Lock's solution is given. In mild haemodilution (i.e. a reduction in haematocrit by a fourth) the volume of blood drained should approximate 800 ml, the volume of infusion given – 1,100–1,200 ml (rheopolyglukin – 400 ml, Ringer's solution – 500 ml, 20% albumin – 100 ml). Significant haemodilution (i.e. a reduction in haematocrit by one-third) involves drainage of about 1,200 ml, infusion of about 1600 ml (rheopolyglukin – 700 ml, Ringer's solution – 750 ml, 20% albumin – 150 ml).

Haemodilution aimed at reducing the amount of blood lost at operation does not necessarily involve drainage the patient's blood. This can be achieved by infusing solutions with high colloid properties, that can increase the circulating blood volume (e.g. albumin, polyglukin, gelatinol) in combination with blood replacement solutions (Ringer's solution).

Plasma autologous transfusion

Replacement of lost blood can be done with the patient's own plasma to provide an ideal blood substitute and prevent homological blood syndrome. Plasma autologous transfusion can be used to replace lost blood when collecting the blood for subsequent autologous transfusion. Thus plasma is obtained through plasmopheresis and then preserved; 500 ml of plasma are considered the safe dose that can be drawn at a time. Drainage can be repeated in 5–7 days. Glucose-citrate solution is used as the preservative. To replace the blood lost at surgery, autologous plasma is used as a blood substitute or as the main blood component. The combination of autologous plasma and washed red blood cells prevents homological blood syndrome. To achieve this, about 1,000 ml of autologous plasma are required.

METHODS OF BLOOD TRANSFUSION

Intravenous blood transfusion is the main method of blood transfusion. Most often, puncturing the cubital or subclavian veins is used. A venesection is only rarely used. To puncture the cubital vein, a tourniquet is applied to the lower third of the upper arm, the puncture site is cleansed with alcohol or iodine and isolated with a sterile material. The tourniquet should compress only the veins leaving the arteries patent. With several fist clenching and contracting the forearm muscles the veins engorge and can be easily identified.

Using a wide lumen needle (with or without a syringe) the skin is punctured, through the subcutaneous tissue, the needle is inserted further (about 1 cm) over the subcutaneous vein and then the anterior wall of the vein is punctured. The needle is then inserted into the vein. The appearance of blood from the needle or in the syringe suggests successful venipuncture. Three to five millilitres of blood are taken from the vein for group and Rh typing and compatibility test. Further, the tourniquet is removed and a blood giving or infusion set is attached to an infusion solution (e.g. normal saline) to prevent blood from clotting in the needle. The needle is fixed to the skin with some adhesive plaster. Subsequently, the blood giving set is attached and transfusion started.

In case the superficial veins cannot be punctured (e.g. collapsed veins in shock, marked obesity) transfusion is done through a venesection. The puncture site is cleansed with alcohol or iodine and isolated with a sterile material. The site of incision is infiltrated with 0,25% novocain. A tourniquet is applied to compress only the veins leaving the arteries patent. The skin and subcutaneous tissues are incised and a forceps is used to expose the vein. Two ligatures are passed beneath the vein, the peripheral one serving as the retractor. Pulling the vein by the retractor, it is punctured directing towards the centre, a pair of scissors can also be used to slit open the anterior wall and the needle or vein catheter is inserted through. The central ligature is used to fix the needle. The blood giving set is then attached to the needle and the skin is closed with two or three sutures.

At the end of transfusion, when about 20 ml of blood is left in the system, it is closed and the needle removed. The place of puncture or venesection is cleaned with iodine tincture and pressing bandage applied.

In cases when long-term (i.e. for several days) infusion of solutions, blood and its components is anticipated, venipuncture of either the subclavian or external jugular is preferred, a special catheter, which can stay for long periods (up to a month) is

placed in the vein and blood or infusion sets can be attached for transfusion, when needed.

Intra-arterial blood transfusion is indicated for:

- clinical death (respiratory and cardiac arrests) caused by massive blood loss
- severe traumatic shock with persistently low systolic arterial blood pressure of less than 60 mm Hg
- ineffective intravenous blood transfusion.

Therapeutic effects of intra-arterial transfusion are assessed based on the reflective stimulation of cardiovascular functions and restoration of coronary blood circulation. To achieve this, blood has to be given at a rate of 200–250 ml for $1^1/_2$–2 minutes and under the pressure of 200 mm Hg; on restoration of cardiac functions the pressure is reduced to 120 mm Hg. When the pulse is clearly felt, intravenous infusion is started; when the systolic pressure is stabilised at 90–100 mm Hg, the needle is removed from the artery.

The system for intra-arterial blood transfusion (fig. 36) is similar to the intravenous one, with the exception being that the long needle in the bottle is attached to Richardson's tube used to pump in air, which, in turn, is connected to a manometer. The artery is punctured through the skin or arteriosection is done.

The femoral and brachial arteries are used for transfusion. Arteriosection is often necessary, using the radial and posterior tibial arteries. The manipulation is done using local infiltration anaesthesia.

Pumping blood under pressure can be associated with a great risk of air embolism. It is therefore recommended that the blood flow in the system be monitored to be able to promptly close it, if necessary.

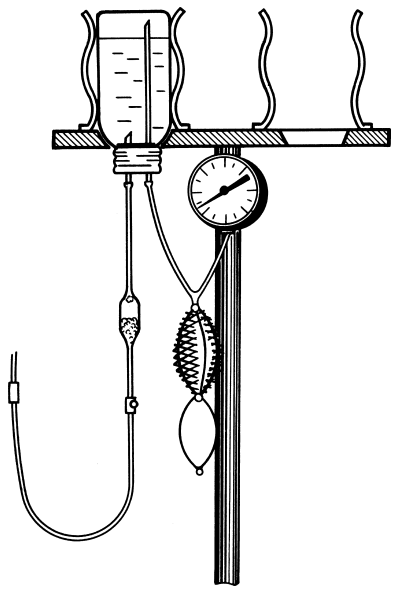

Fig. 36. The system for intra-arterial blood transfusion.

Intra-aortal blood transfusion

It is used in sudden clinical death, massive bleeding resulting from thoracic surgeries. Intra-aortal blood transfusion can be done with the help of a catheter inserted into the aorta through one of the peripheral arteries (often the femoral, rarely brachial) by means of a puncture or section. In the case of intra-arterial transfusion this is done under pressure and with the use of the same type of systems.

Intra-osseous transfusion

This method is only used when it is not possible to transfuse blood through other means (e.g. in severe widespread burns). Blood is transfused into the sternum, the iliac crest and the heel bone.

Puncture of the sternum is done with the patient lying supine. It is punctured under local anaesthesia into the shaft or body of the sternum. It is Kassirsky's needle that is used for this puncture. The operation site is cleansed. Injection is strictly made in the midline, passing through the skin, subcutaneous tissues; the initial resistance is at the bony lamella of the sternum, which is overcome with some effort. A specific feeling of the needle indicates that it has reached the bone marrow. The mandrin is removed and a syringe is used to aspirate the bone marrow. The appearance of the latter in the syringe indicates that the needle is positioned correctly, 3–5 ml of 1–2% novocain (procaine) are then injected into the bone marrow and the transfusion system is attached.

The iliac crest is punctured in the centre of the posterior third since in this area the spongy layer of bone has a loose structure that makes it easier to transfuse.

Flow of blood should be as slow as 5–30 drops/minute, the transfusion of 250 ml of blood, therefore, takes 2–3 hours. To accelerate the flow, raise the bottle or increase the pressure in the bottle by injecting air under pressure up to 220 mm Hg.

THE PROCEDURE OF BLOOD TRANSFUSION

Blood transfusion is a serious operation which consists in transplantation of human living tissues. This method of treatment is widespread in clinical practice. Health care professionals of different specialities perform blood transfusion: surgeons, obstetrician and gynaecologists, traumatologists, internists, etc. Up-to-date scientific advancements, especially those in transfusiology, help prevent the complications associated with blood transfusion, which can sometimes even lead to death. These complications occur because of the errors that are committed in the process, which result from inadequate knowledge of the essentials of transfusion or viola-

tion of whichever step of the procedure. These include the inappropriate decisions as to the indications or contraindications for blood transfusion, errors in blood group and Rh typing, misinterpretation of the results of compatibility tests, etc. Observing the rules and regulations and following the steps of the procedure are bound to lead to successful blood transfusion.

Indications for blood transfusion. As blood transfusion is a serious intervention for each patient, it must always be justified. If it is possible to avoid the procedure or the benefits expected from blood transfusion are unlikely, the procedure should always be avoided. The indications for blood transfusion depend on the effect it is supposed to achieve: replacement of deficient blood volume or its components; improvement of the clotting properties of blood in case of bleeding disorders. Blood transfusion is absolutely indicated for acute blood loss, shock, bleeding, severe anaemia, major traumatic operations, including those with heart-lung bypass. Diseases of blood, pyogenic infections and severe intoxication are all indications for transfusing blood or its components.

Contraindications for blood transfusion

1. Decompensated cardiac disease.
2. Septic endocarditis.
3. Advanced hypertension (i.e. with numerous complications).
4. Cerebral vascular thromboembolism.
5. Pulmonary oedema.
6. Acute nephritis.
7. Severe hepatic failure.
8. Generalised amyloidosis.
9. Hypersensitivity.
10. Bronchial asthma.

An important role in the evaluation of contraindications to blood transfusion play the patient's transfusion and allergic histories, i.e. the information on previous blood transfusions and their outcome as well as the presence of an allergic condition.

Risk group patients should be identified. These are the patients who had blood transfusions more than 3 weeks ago, accompanied by complications; women with the history of miscarriages, pathological pregnancies and births due to neonate haemolytic disease and jaundice; patients with decay of a malignant tumour, diseases of the blood with chronic purulent infections. The cases with complicated blood transfusions and unfavourable obstetric history are to be suspected of having been sensitised to Rh. In such a case blood transfusion has to be postponed before the presence of antibodies to Rh or any other antigens have been excluded. Compatibility tests of the patients must be done in the laboratory using indirect Coomb's test.

In life-threatening situations (e.g. shock, acute or intractable haemorrhage, severe anaemia, major traumatic operations) blood transfusion may has to be performed in spite of the contraindications. In such a case it is advisable to choose certain blood components or its preparations and take the necessary prophylactic measures. For instance, when blood transfusion is urgently needed in a patient with hypersensitivity or bronchial asthma, desensitising agents (e.g. calcium chloride, antihistamines, corticosteroids) are given before the procedure, and the blood components with minimal amounts of antigen (e.g. washed and frozen red blood cells) are used. It is better to combine blood with blood substitutes that have specific properties, and during operations, if possible, transfuse autologous blood.

Preparing for blood transfusion. Each patient admitted to the surgical unit must be investigated for blood grouping and Rh. Cardiovascular and respiratory systems, the kidneys and urinary tract should be examined to rule out contraindications for blood transfusion. Routine blood tests are performed 1–2 days prior to blood transfusion. Immediately before the procedure the patient has to urinate and defecate, if possible. The transfusion should preferably be performed in a fasting patient or after a light breakfast.

Methods and types of products for transfusion

In anaemia, leucopenia, thrombocytopenia and clotting disorders when particular blood components are deficient, transfusion of whole blood is not justified. The whole blood therapeutic effects in such cases are therefore low whilst the waste of blood is unreasonably high. Instead, concentrated blood components (e.g. red blood cell or leucocyte mass, plasma, albumin) are to be used. Patients with haemophilia, for example, will only need transfusion of factor VIII. Again, instead of giving litres of whole blood, the therapeutic effect can be achieved by giving only a few millilitres of antihaemophilic globulin. In hypo- and afibrinoginaemia, up to 10 l of whole blood may be needed to compensate for the deficit in fibrinogen, whereas only 10–12 g of the blood product of fibrinogen may suffice. Besides, transfusion of whole blood can lead to sensitisation of the patient, the formation of antibodies to blood cells (leucocytes, platelets) or plasma proteins, which can cause serious complications during subsequent blood transfusions or pregnancies. Transfusion of whole blood is indicated in acute haemorrhage with a dramatic decrease in the circulating blood volume, in exchange blood transfusions, in heart-lung bypass during open heart surgeries.

It is recommended that the product for transfusion contain the components of blood that the patient needs most of all (tab. 3).

Examination of preserved blood and its components before transfusion. The blood to be transfused has to be examined for viability (fig. 37, colour inset): the wholeness of the package, expiring date and possible violations of storage (frozen or otherwise overheated). The best blood to transfuse is the one that has not been stored for more than 5–7 days, since a longer storage period may result in biochemical and morphological changes which reduce the positive properties of blood. Macroscopically, blood should have three layers. The red layer of red blood cells is located at the base followed by a thin layer of leucocytes and the top transparent yellowish layer of plasma. Signs which show that blood is not fit for transfusion are as follows: red or pink discoloration of plasma (haemolysis), the presence of flakes, cloudiness, the presence of a film on the surface (signs of contamination), the presence of clots (clotted blood). In emergency blood transfusions some of the blood is put in a glass tube and centrifuged. Pink discoloration of plasma indicates haemolysis. To transfuse frozen blood components the package is quickly warmed to 38 °C, the cryostabiliser (glycerin for red blood cells and dimethyl sulphoxide for leucocytes and platelets) is then washed off red blood cells.

Cross-matching (i.e. checking) the blood groups of the donor and recipient's blood. Although the data from the patient's case history may coincide with those on the the labels on the blood bag, it is necessary to repeat typing the patient's blood group of the patient that of the blood to be transfused immediately before the procedure. It is the physician who will perform transfusion is responsible for checking. In emergency transfusion, apart from checking the blood group by the ABO system, Rh is checked using the express method. The grouping is done according to the stipulated rules and regulations and the results are observed not only by the doctor performing the transfusion but also by other doctors.

Testing for compatibility. To check for individual compatibility 3–5 ml of blood is taken from the patient's vein, this is centrifuged or allowed to stand. One big drop of the serum is then put on a plate or flat surface. A drop of donor blood is placed nearby at the ratio of 5:1 – 10:1, mixed together by a glass rod or the slide edge and observed for 5 minutes, after which a drop of normal saline is added and the result determined by the presence or absence of agglutination. The absence of agglutination indicates that the blood groups of the patient and the donor are compatible, and the presence of it means incompatibility (fig. 38, colour inset). This checking for compatibility is to be performed on each bag of blood that is to be transfused. Checking for compatibility of the Rh is done in the case of unfavourable transfusion history (previous post-transfusion reactions, Rh conflict pregnancies, miscarriages), in critical conditions when it is not possible to recheck the patients Rh, and in a case when the patient with unknown Rh has to receive Rh positive blood. Blood is taken from the vein like in checking individual

Table 3. Indications of transfusion solutions

Indication	Blood and blood products									
	whole blood	RBC	WBC	platelets	plasma	albumin	cryo precipitate	fibrinogen, thrombin	immunoglobulin	blood substitutes
Acute haemorrhage:										
10–15% CBV										+
15–30% CBV		+				+				+
30% + CBV	+					+				+
Shock		+				+				+
Anaemia		+								+
Thrombocytopenia				+						
Leucopenia			+				+	+		+
Haemophilia							+	+		
Bleeding	+				+					+
Hypo-, disproteinemia					+	+				+
Pyogenic infections					+	+			+	+

compatibility for grouping, centrifuged, a drop is put into the Petri dish and a smaller drop (3–5 times smaller) of the donor blood is added, mixed together, covered and allowed to float on a water bath at 42–45 °C for 10 minutes. The checking is better done in light using a magnifying glass. The absence of agglutination allows for the transfusion of blood in that package. The presence of agglutination indicates that the patient's blood is Rh negative, and contains anti-rhesus antibodies (fig. 39, colour inset). Such a patient can only be transfused with Rh negative blood. Compatibility test for the Rh has to be done on each donor pack that is to be transfused. If true agglutination is encountered in the process of the ABO system and Rh tests, the specific donors have to be searched for the particular patient through the blood bank. Assuming the patient's condition is critical and urgent blood transfusion is needed, a search is done through the available stock without waiting for an answer from the blood bank. Blood is chosen from the same group and Rh. Blood from each pack is tested with the serum of the patient according to the ABO system and the Rh for compatibility. If agglutination does not occur, that blood can be transfused starting with the biological test. In case the tests from all the existing blood in stock with the same groupand Rh give positive reactions of agglutination, none of them can be transfused and the patient will have to wait for an individual donor to be found through the blood bank.

If such blood is received through the blood bank, it still has to be grouped and cross-matched again for the ABO system and Rh as well as for individual compatibility. It is only when the patient's blood is of the same group and Rh with the donor blood and there is no sign of agglutination in the compatibility tests for the ABO system and Rh that the blood can be transfused always starting with the biological test.

Preparation for transfusion. Blood is transfused through a disposable plastic system with nylon filter preventing blood clots from entering the blood stream (fig. 40). The system consists of a short tube with a needle and filter for allowing air into the bottle, a long tube for the infusion of blood with a needle at each end – one to put into the bottle and the other to puncture the patient's vein. The system is fitted with a dropper, nylon filter and a plastic clamp to regulate the rate of infusion. They are produced in sterile forms packed into polyethylene bag which should be opened only immediately before use.

Transfusion sets that can be used for several times are not advisable since they are not equipped with micro filters. However, when needed, a non-pyrogenic tube has to be used, a glass dropper that controls the rate of flow is mounted onto it, and a glass

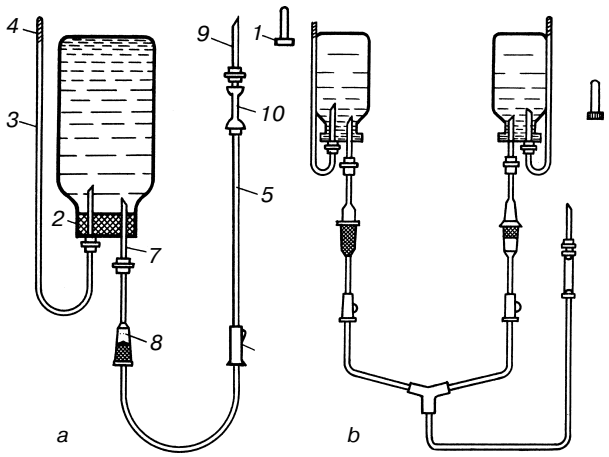

Fig. 40. The blood and fluid infusion system.
(*a*) the mounted system: *1* — needle cover; *2* — bottle filled with blood; *3* — air-way tube; *4* — air-filter; *5* — transfusion tube; *6* — clamp for regulating the blood flow rate; *7* — needle for blood flow from the bottle; *8* — dropper filter; *9* — needle for venepuncture; *10* — joining tube; (*b*) multi-bottle blood and fluid infusion system.

tube attached towards the outlet controls the complete exit of air out of the tube while filling with blood. To attach the system to the bottle, two special needles – a long and short ones which are inserted through the rubber cork of the bottle. The longer needle is inserted as deep as the bottom of the bottle, and it is through it that air escapes during the time of transfusion, the shorter needle is attached to the plastic tube for transfusion, onto which the plastic clamp is fitted; the bottle is turned upside down and hung on the drip stand. The system is subsequently filled with blood after all the air has been expelled from it.

Mounting the system for transfusion one should abide by the following regulation: *transfuse blood from the bottle in which it has been prepared and stored*.

When transfused from a plastic bag, blood is first mixed by shaking the bag, a clamp is put on the central outlet tube, alcohol or 10% iodine is used to cleanse the tube which is cut at about 1–1,5 cm below the clamp. The safety cap of the system is removed and attached to the system by way of attaching the tube end of the bag to the cannula of the system. The bag of blood is hung upside down onto the drip stand, the system with the dropper is raised and turned so that the filter in the dropper is situated on the upper part. The clamp is removed from the tube; the dropper is half filled with blood before the clamp is reapplied. The system is put back to its original position with the filter downwards and must be filled with blood. The clamp is removed and that part below the filter is filled with blood until all the air in it is evacuated and blood drops start coming out of the needle. A few drops of blood are let onto

the plate for onward control determination of the grouping, Rh of the donor blood and compatibility. The system is checked through observation to make sure there are no air bubbles inside. The system is now ready for use. The rate of infusion is regulated with the clamp. When it is necessary to change an empty bag with a new one, the system is closed with the clamp, a few forceps are used to clamp the tube, the old bag is removed and a new one attached.

Blood transfusion using the standard bottle. The top of aluminium cap is removed, the adjacent rubber cork is then cleansed with alcohol or iodine tincture and punctured with two needles. A short tube is attached to one of the needles for air passage, the end of which placed above the bottom of the bottle, and to the other needle is attached the disposable system with the bottle hung upside down on the drip stand. The system is filled with blood as mentioned above.

After mounting the system and determination of the grouping and Rh as well as the compatibility tests blood transfusion can be started. The system is attached to a needle that has previously been inserted into the vein with some solution for infusion already running.

The test for biological compatibility. Transfusion of blood or its components (red blood cell mass, red blood cell suspension, plasma) has to be preceded by the biological test for compatibility. To perform this test, the first 15–20 ml of blood are allowed to flow fast; the infusion is stopped and the patient's response and condition are observed (behaviour, skin colour, pulse and breath rates). Tachycardia, dyspnoea, facial hyperaemia and hypotension all suggest incompatibility of the donor's blood with that of the recipient. In the absence of signs of incompatibility the test is repeated twice, and if there are still no reactions the blood transfusion is continued. During the triple biological test the needle can be thrombosed when the infusion is halted. To prevent this when infusion is supposed to have been halted, it can be allowed to drop at a very slow rate or if blood substitutes are to be given with the blood, they can be given in those intervals.

Supervision of blood transfusion. The rate of flow is regulated with a special clamp. Blood is to be given in drops at a rate of 50–60 drops/minute. If fast flow of blood is needed, the clamp is fully opened, or a Richardson's cylinder can be attached to pump in air into the bottle (transfusion under pressure).

The patient has to be closely observed throughout the whole period of transfusion, so that in case there are any complications or reactions they can be noticed, and transfusion stopped early enough to start therapeutic measures.

If the lumen of needle is blocked by a thrombus, it is not advisable to use any solutions or the mandrin as it may push the thrombus further into the patient's vein. In such a case it is advisable to clamp the system, disconnect it from the needle, remove the thrombus from the vein and apply a pressure bandage; a new needle is then used to puncture a new vein to continue with the transfusion.

It is allowed to mix sterile intact blood substitutes that are in standard packages with the blood in the process of blood transfusion.

Transfusion is stopped when about 20 ml of blood are left in the bottle, ampoule or plastic bag. The needle is removed and a sterile dressing is bandaged on the puncture site. The blood left in the bottle is stored under sterile conditions in the refrigerator at 4 °C for 48 hours. In case the patient develops a reaction later this left over blood can then be used to investigate the cause of the complication (checking for bacterial contamination, blood group and Rh cross-matching, retesting for compatibility of the donor blood with the patient's blood).

Recording blood transfusion. Every blood transfusion must be recorded into a special book meant for this purpose as well as into the patient's case history. Such information as the amount of blood given, the data written on the given blood pack, the result of the compatibility test and reactions or complications, if any, are to be noted.

Monitoring the patient after blood transfusion. The patient who has undergone blood transfusion should stay in bed for at least 3–4 hours. They have to be followed for 24 hours by the doctor and nurse. The patient's symptoms and signs (e.g. retrosternal or lumbar pain, cutaneous changes like pallor or cyanosis fever, tachycardia or hypotension) are assessed and precisely registered. An hourly check of pulse and temperature is done for the first four hours. A routine blood and urinalysis should be performed the following day. Post-transfusion reactions require that urgent therapeutic measures be taken. Normal body temperature for the first four hours suggests that no reaction occurred after transfusion.

COMPLICATIONS OF BLOOD TRANSFUSION

Blood transfusion is considered to be a safe method of treatment if all the rules and regulations are carefully followed. Violation of the regulations, underestimation of contraindications, and technical errors can lead to serious post-transfusion reactions and complications.

Blood transfusion reactions. Unlike complications, these do not result in serious bodily dysfunctions and are therefore usually not life-threatening. They may be either pyrogenic or anaphylactic and

occur promptly after transfusion. Their manifestations are as follows: fever, malaise and adynamia, rigors, headache, itching, Quincke's oedema.

Half of all the reactions and complications are due to pyrogenic reactions which may be mild, moderate or severe. In a mild reaction, the body temperature increases by 1 °C and the patient complains of headache and muscle pain. A moderate reaction involves rigors, a body temperature increase by 1,5–2 °C, tachycardia and dyspnoea. Severe reactions are characterised by rigors, a body temperature rise by more than 2 °C to as high as 40 °C, severe headaches, pains in the muscles and bones, tachycardia, labial cyanosis and dyspnoea.

The pyrogenic reactions are mediated by the products of plasma protein decay, leucocytes of the donor's blood, products of microbial activity, breakdown of plasma and blood particles left over from previous transfusions.

In a pyrogenic reaction, the patient should be covered with warm clothing and hot water bottles applied to the feet, he/she should be given hot drinks as well as paracetamol. If it is a mild or moderate reaction, these measures may suffice. In severe reactions, apart from the above-mentioned measures, the patient is given promedol, analgin in injections, 5–10 ml of 10% calcium chloride and solutions of glucose are given intravenously. To prevent pyrogenic reactions in patients with severe anaemia, washed and frozen red blood cells should be transfused.

Allergic reactions because of the recipient's body being sensitive to immunoglobulins occur mostly in repeated transfusions. Clinical manifestations of anaphylaxis include rigors, fever, malaise, urticaria, dyspnoea, suffocation, nausea, vomiting. Antihistamines and desensitising agents (dimedrol, suprastin, calcium chloride, corticosteroids) are used, in case of vascular insufficiency vasopressors are administered.

Complications of blood transfusion. If blood incompatible mainly by the ABO group and Rh systems is transfused, the patient develops blood transfusion shock resulting from rapid intravascular haemolysis of the transfused blood. The main reasons of incompatibility of blood are technical errors.

The three degrees of shock are identified: degee 1 – a fall in systolic blood pressure to 90 mm Hg, degee 2 – a fall in systolic blood pressure to 80–70 mm Hg, degee 3 – a fall in systolic blood pressure below than 70 mm Hg.

The following periods are identified in the course of blood transfusion shock:

1) blood transfusion shock per se;
2) oliguria and anuria;
3) restoration of diuresis;
4) recovery.

Clinical symptoms and signs of shock can occur at the beginning of the procedure following transfusion of only 10–30 ml of blood, at the end of transfusion or immediately after transfusion. These usually involve restlessness, pain and a sensation of retrosternal uneasiness, lumbar or muscle pain, and sometimes rigors; the patient is dyspnoeic, tachycardic and hypotensive, his/her face being hyperaemic, sometimes pale or cyanotic. The may also experience nausea, vomiting, enuresis or even encopresis. Fulminant development of these manifestations may be fatal.

If incompatible, blood is transfused to a surgical patient under general anaesthesia during operation these signs of shock may manifest mildly, if at all. In such cases incompatibility is identified by the increase or decrease in blood pressure, cyanosis of the skin and visible mucus layer, an increase sometimes very pronounced bleeding tendencies of tissues in the operation wound. When the patient recovers consciousness, they may have tachycardia, hypotension, and acute respiratory arrest.

Clinical manifestations of blood transfusion shock after transfusing Rh incompatible blood occur after 30–40 minutes, and occasionally several hours after transfusion.

During recovery from blood transfusion shock, they can develop acute renal failure. Oliguria, hyposthenuria and progressing uraemia may be evident in the first few days. Progression of acute renal failure can lead to a cessation of urine production, or *anuria*. The levels of products of protein degradation, urea and bilirubin start to increase in the blood. In severe cases the period can last for 8–30 days. In favourable situations, the signs of renal failure subside, diuresis is gradually restored and the patient enters the recovery period. If uraemia sets in, death usually occurs within 3–15 days.

With the early signs of blood transfusion shock, transfusion must be stopped and intensive therapy started.

1. Cardiovascular agents like strophanthin, corglucon (in cardiovascular failure), norepinephrine (in hypotension), dimedrol, suprastin or diprazin are used as antihistamines, corticosteroids (50–150 mg of prednisolone or 250 mg of hydrocortisone) are given to stimulate vascular tone and inhibit the antigen – antibody reaction.

2. To accelerate the restoration of circulation rheopolyglukin and saline solutions are given.

3. To remove the products of haemolysis hydrocarbonate and sodium lactate are given.

4. To support diuresis haemodes, lasix and mannitol are given.

5. To reduce spasm of the renal vessels an emergency bilateral paranephric novocain (procaine) blockage is done.

6. Oxygen therapy is given and in respiratory failure artificial ventilation of the lung is provided.

7. Ineffective drug therapy of acute renal failure and progressing uraemia is an indication for haemodialysis or haemabsorption.

Bacterial – toxic shock only rarely occurs. It is caused by contamination of the blood during its preparation or storage. Complications occur either during transfusion or within 30–60 minutes. Rigors occur suddenly, fever, anxiety, semi-consciousness, fast and thready pulse, marked hypotension, enuresis and encopresis.

Bacteriological investigation of the blood left after transfusion plays a major role in confirmation of the diagnosis.

Treatment is by means of immediate antishock transfusion, detoxication and antibacterial substances, analgesic and vasoconstrictors (norepinephrine), solutions with rheologic and desintoxicating properties (rheopolyglukin, haemodes), electrolyte solutions, anticoagulants, broad-spectrum antibiotics (aminoglycosides, cephalosporins).

Most effective is the complex therapy with exchange blood transfusion.

Air embolism. This may be due to defective of transfusion techniques, namely incorrect filling of the blood giving system which results in air having been left in the tubes, when transfusion under pressure is not duly stopped. In such situations air can enter the patient's vein, reach the right cardiac chambers and obstruct the pulmonary artery and its branches. Air embolism may result from an instant entry of as much as 2–3 cm^3 to the vein. Clinical signs of air embolism of the pulmonary artery are severe chest pain, dyspnoea, cough, cyanosis of the upper trunk, fast weak pulse and hypotension. The outcome is often unfavourable. With the early signs of embolism, transfusion must be stopped and resuscitation started: artificial ventilation, cardiovascular drug therapy.

Thromboembolism secondary to blood transfusion results from migration of a vein thrombus. The clinical features of this complication are similar to those of air embolism. Small thrombi obstruct smaller branches of the pulmonary artery causing lung infarction, whose clinical signs being as follows: chest pain, cough (progressing from being dry to that with bloody sputum), fever. Chest x-rays show signs of focal pneumonia.

With the early signs of thromboembolism transfusion must be stopped and cardiovascular drugs, oxygen, fibrinolysin, streptokinase and heparin given.

Transfusing an amount of donor's blood above 40–50% of the circulating blood volume (i.e. about 2–3 l) within a short period (up to 24 hours) is referred to as *massive blood transfusion*. In transfusing such an amount of blood (especially after long storage) from different donors there is a risk of *massive blood transfusion syndrome*. The factors that contribute to its development are as follows:

- exposure of blood to cold (refrigerator);
- administration of excessive amounts of sodium citrate and products of blood decay (e.g. potassium, ammonia), which accumulate in plasma during its storage;
- administration of excessive amounts of fluid that enters the blood stream and overloads the cardiovascular system.

Acute cardiac dilation of the heart results from large amounts of preserved blood being infused rapidly or under pressure. The clinical picture includes dyspnoea, cyanosis, right hypochondriac pain , fast weak arrhythmic pulse, arterial hypotension with venous hypertension. When there are signs of cardiac overload, transfusion should be stopped, cardiac drugs (strophanthin, corglucon) as well as vasoconstrictors and 10 ml of 10% calcium chloride is given.

Massive transfusion may cause *citrate intoxication*. The toxic dose of sodium citrate is considered to be as much as 0,3 g/kg. Sodium citrate interacts with calcium ions in the recipient's blood and causes hypocalcaemia, which, combined with accumulation of citrate in the blood, leads to severe intoxication. The signs of the latter are as follows: tremor, twitching, fast pulse, hypotension, arrhythmia. In severe cases dilation of the pupils, cerebral and pulmonary oedema can be evident. To prevent citrate intoxication, it is required that following transfusion of each 500 ml of preserved blood 5 ml of 10% calcium chloride be given. To neutralise sodium, citrate solutions of calcium gluconate and calcium chloride are administered.

The transfusion of blood that has been stored for a long period (more than 10 days) can be followed by severe potassium intoxication that leads to ventricular fibrillations and further to cardiac arrest. Clinically, hyperkalaemia involves bradycardia, arrhythmia, myocardial atony. Prevention of potassium intoxication consists in transfusion of blood that has been stored for a short time (maximum 3–5 days) or the use of washed and frozen red blood cells. As a therapeutic measure, 10% calcium chloride, normal saline, 40% glucose with insulin as well as cardiac preparations are given.

In massive blood transfusions when compatible blood of the same group and Rh, obtained from different donors is transfused, individual incompatibility of plasma proteins can cause the development of a serious complication known as *homological blood syndrome*. Clinical signs of the syndrome include skin pallor with bluish discoloration, dysp-

noea, anxiety, cool skin on touch, fast and weak pulse, arterial hypotension with venous hypertension. Multiple rhonchi are audible on auscultation of the lungs. Haematocrit falls and the circulating blood volume dramatically decreases, although sufficient blood has already been transfused; the blood clotting time slows down. A microcirculatory defect, red cell stasis, microthrombosis and deposition of blood all contribute to the pathogenesis of this syndrome.

Prevention of the syndrome of homological blood involves replacement of blood loss depending on the circulating blood volume and its components. It is important to combine donor's blood with antishock solutions (polyglukin, rheopolyglukin) that improve the rheologic properties of blood (fluidity) because of dilution of blood, reduction of its viscosity and acceleration of microcirculation.

In massive transfusion it is not necessary to fully replace the concentration of haemoglobin. To maintain the transport function of blood haemoglobin blood levels of at least 75–80 g/l will suffice. To replace the deficit in the circulating blood volume, solutions must be used. Of great importance in prevention of the syndrome of homological blood is autotransfusion of blood and plasma, i.e. the transfusion of absolutely compatible transfusion solutions as well as washed and frozen red blood cells.

Infectious complications. These include acute infections (e.g. influenza, measles, typhoid, brucellosis, toxoplasmosis) and diseases that are transmitted through serum (e.g. hepatitis B, C, HIV, cytomegalovirus infection, malaria). Prevention of such complications involves thorough choice of donors, education of donors, proper management of the blood banks' and blood stations' work.

TESTS

Chapter V. BLOOD TRANSFUSION

1. Which blood component contains agglutinin?
A. Serum.
B. White blood cells.
C. Red blood cells.
D. Platelets.
E. Monocytes.
Choose the correct answer.

2. Agglutinogens are contained in one of the following blood components:
A. Plasma.
B. Serum.
C. White blood cells.
D. Red blood cells.
E. Platelets.
Choose the correct answer.

3. During blood grouping, the reaction of agglutination appeared positive with standard sera of groups 0 and B and negative with the one of A group. The blood examined is therefore of which of the following groups:
A. 0.
B. A.
C. B.
D. AB.
Choose the correct answer.

4. During blood grouping, the reaction of agglutination appeared positive with standard sera of groups 0 and A and negative with the one of B group. The blood examined is therefore of which of the following groups:
A. 0.
B. A.
C. B.
D. AB.
Choose the correct answer.

5. During blood grouping, the reaction of agglutination appeared positive with standard sera of groups A and B and negative with those of 0 and AB groups. The blood examined is therefore of which of the following groups:
A. 0.
B. A.
C. B.
D. AB.
E. Inadequate standard sera.
Choose the correct answer.

6. During blood grouping with cyliclones, the reaction of agglutination is negative with anti A- and B- cyliclones. The blood under examination is therefore of group:
A. 0.
B. A.
C. B.
D. AB.
Choose the correct answer.

7. Agglutination is positive with anti A- cyliclones and negative with anti B- ones. The blood under examined is therefore of group:
A. 0.
B. A.
C. B.
D. AB.
Choose the correct answer.

8. Agglutination is observed with anti A- and anti B- cyliclones. The blood under examination is therefore of group:
A. 0.

B. A.
C. B.
D. AB.
Choose the correct answer.

9. Agglutination has occurred with anti B-cyliclones. The blood under examination is therefore of group:
A. 0.
B. A.
C. B.
D. AB.
Choose the correct answer.

10. During blood grouping with cyliclones, monitoring the reaction of agglutination should last for:
A. 3–5 seconds.
B. 20–30 seconds.
C. 1 minute.
D. 2 minutes.
E. 2,5 minutes.
Choose the correct answer.

11. Testing for individual blood compatibility requires:
A. The patient's plasma or serum and donor blood.
B. Donor plasma and the patient's blood.
C. The patient's blood components and donor blood.
D. Donor blood components and the patient's blood.
E. Donor blood and the patient's blood.
Choose the correct answer.

12. In which of the following conditions is blood transfusion indicated:
1. The patient's allergic condition.
2. Shock.
3. Hepatic or renal insufficiency.
4. Blood loss.
5. Vitamin deficiency.
Choose the right combination of answers:
A. 1, 2. B. 1, 3. C. 2, 3. D. 2, 4. E. 4, 5.

13. The signs of transfusion of inappropriate blood are as follows:
1. An increase in the packed cell volume or haematocrit.
2. Rigors.
3. Fever.
4. Lumbar pain.
5. Tachycardia.
Choose the right combination of answers:
A. 1, 2, 3, 4. B. 2, 3, 4. C. 1, 3, 4, 5. D. 2, 4, 5. E. 2, 3, 4, 5.

14. The sites of intraosseous blood transfusion are as follows:
1. The iliac crest.
2. The femoral diaphyses.
3. The calcaneus.
4. The sternum.
5. The tibial metaphyses.
Choose the right combination of answers:
A. 1, 2, 3. B. 2, 3, 4. C. 1, 3, 4. D. 1, 3, 5. E. 1, 2, 5.

15. The indications for blood transfusion are as follows:
1. Acute blood loss.
2. Suppurative intoxication.
3. Acute thrombophlebitis.
4. Acute tuberculosis.
5. Shock.
Choose the right combination of answers:
A. 1, 2, 5. B. 2, 3, 5. C. 3, 4, 5. D. 2, 4, 5. E. 1, 3, 5.

16. The optimal temperature of blood storage is one of the following:
A. 0 +1 °C.
B. +4–+6 °C.
C. +8–+10 °C.
D. -1 °C.
E. -2 °C.
Choose the correct answer.

17. The blood lost in which of the following conditions is suitable for reinfusion?
1. Tubal pregnancy.
2. Rupture of the intestine.
3. Rupture of the spleen.
4. Rupture of aortic aneurysm.
5. Rupture of the gall bladder.
Choose the right combination of answers:
A. 1, 2, 3. B. 2, 3, 5. C. 3, 4, 5. D. 1, 3, 4. E. 1, 5.

18. The indications for intra-arterial blood transfusion include which of the following:
1. Sever shock.
2. Preagonal condition as a result of acute blood loss.
3. Clinical death.
4. Preoperative assessment.
5. Surgical operation.
Choose the right combination of answers:
A. 1, 2, 3, 4. B. 1, 3, 4. C. 1, 2, 4. D. 1, 2, 3. E. 1, 2, 3, 4, 5.

19. The patient with trauma (brain injury plus hip fracture) has degree III traumatic shock (BP–70/40 mm Hg, pulse – 120/min). The intensive therapy before hospitalization includes:
1. Blood transfusion.
2. Immobilization of the lower limb.
3. Nutritional support (polyglucin, rhepolyglukin, gelatinol).
4. Anaesthesia with non-narcotic anaesthetics.
5. Administration of vasoconstrictors to raise blood pressure.
Choose the right combination of answers:
A. 1, 2, 3, 4, 5. B. 1, 2, 4. C. 2, 3, 4, 5. D. 2, 4, 5. E. 1, 4, 5.

20. The clinical manifestations of blood transfusion shock are as follows:
1. Abdominal pain.
2. Tachycardia.
3. Bradycardia.
4. Hypotension.
5. Lumbar pain.
Choose the right combination of answers:
A. 1, 2, 3. B. 2, 4. C. 3, 4, 5. D. 2, 4, 5. E. 1, 3, 4, 5.

21. To prevent citrate intoxication during stored blood transfusion, it is necessary to administer:

A. 500 ml of stored blood.
B. Potassium chloride.
C. Antihistamine agent.
D. Calcium chloride.
E. Sodium bicarbonate.

Choose the correct answer.

22. The sources of blood and blood products are as follows:

1. Donor blood.
2. Autologous blood.
3. Animal blood.
4. Cadaver blood.
5. Placental blood.

Choose the right combination of answers:
A. 1, 2, 3. B. 2, 4, 5. C. 2, 3, 5. D. 1, 2, 4, 5. E. 1, 2, 3, 4, 5.

23. Blood transfusion shock requires the following steps to take:

1. To increase the rate of blood transfusion and quickly complete the transfusion.
2. To begin administration of polyglucin.
3. To provide oxygen inhalation.
4. To perform paranephric block by A. V. Vishnevsky.
5. To quit blood transfusion.

Choose the right combination of answers:
A. 1, 2, 3. B. 2, 3, 4, 5. C. 1, 2, 3, 4. D. 1, 2, 4. E. 1, 3, 4.

24. The reaction most common in patients under anaesthesia during blood transfusion is one of the following:

A. Blood transfusion shock.
B. Increased tissue bleeding.
C. Quincke's disease.
D. Acute hepatic failure.
E. Rigors.

Choose the correct answer.

25. The contraindications for blood reinfusion are as follows:

1. Haemothorax with injury of the major bronchi.
2. Haemoperitoneum with injury of the stomach and intestine.
3. Haemoperitoneum due to a malignant tumour.
4. Blood having been in the abdominal cavity more than 24 hours.
5. Ruptured ectopic pregnancy.

Choose the right combination of answers:
A. 1, 2, 3, 4. B. 2, 3, 4, 5. C. 2, 4, 5. D. 1, 2, 4, 5.

26. The complications due to rhesus incompatibility may occur under the following conditions:

1. Repeated transfusion of Rh positive blood to a Rh negative recipient.
2. Pregnancy of a Rh negative woman with a Rh positive foetus.
3. Transfusion of Rh negative blood to a Rh positive recipient.
4. Pregnancy of a Rh positive women with a Rh negative foetus.
5. Transfusion of a Rh positive donor's plasma to Rh a negative recipient.

Choose the right combination of answers:
A. 1, 3, 4, 5. B. 1, 2. C. 2, 3, 5. D. 2, 4, 5. E. 2, 3, 4, 5.

27. Haemodilution is one of the following:

A. Direct blood transfusion.
B. Blood dilution.
C. Autologous plasma transfusion.
D. Autologous blood transfusion.
E. Exchanging blood transfusion.

Choose the correct answer.