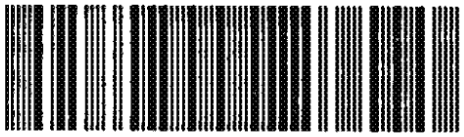
102118

Ministry of Health. Notes on transfusion. Issued, 1954.

NOTES ON TRANSFUSION

ISSUED BY THE MINISTRY OF HEALTH
FOR THE NATIONAL BLOOD TRANSFUSION
SERVICE



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(*Revised and reprinted January* 1954)

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NOTES ON TRANSFUSION

Transfusion therapy should be undertaken only after careful assessment of the patient's clinical condition to determine the nature and quantity of fluid to be transfused, and the rate of administration. The patient may require whole blood, concentrated red cells, or plasma. A transfusion should never be given without a definite indication.

I. Choice of Fluid

1. WHOLE BLOOD is used to restore blood volume or the oxygen-carrying capacity of the blood, or to replace one or more missing elements of the blood. A standard bottle contains approximately 540 ml. citrated blood (approximately 420 ml. blood and 120 ml. acid-citrate-dextrose anticoagulant solution).

Blood is sometimes indicated for:—

(i) Haemorrhage—acute or chronic.

(ii) Certain forms of anaemia—acute or chronic.

(iii) Oligaemic shock.

(iv) Certain blood dyscrasias, e.g., haemophilia, haemorrhagic disease and haemolytic disease of the new born, aplastic anaemia, etc.

2. CONCENTRATED RED CELLS are ideal for the treatment of anaemic states in which it is desired to raise the haemoglobin level, and in which blood volume restoration is not required. A bottle contains the cells from one or more bottles of whole blood, and must not be used more than 24 hours after preparation.

3. PLASMA OR SERUM (dried or fluid) should be reserved for the following conditions:—

(i) Burns and crush injury.

(ii) Hypoproteinaemia.

(iii) Oligaemic shock due to haemorrhage, e.g., blood loss in childbirth or during operation, gastro-intestinal haemorrhage. (Plasma or serum may be used in such emergencies when compatible blood is not immediately available).

A bottle of dried plasma or serum contains the dried solids from 400 ml. citrated plasma (serum). A bottle of fluid plasma contains approximately 500 ml. citrated plasma.

Plasma or serum may be given without regard to the blood group of the recipient. (See Section VII (7).)

4. PLASMA SUBSTITUTES are solutions of macromolecular substances which possess properties (e.g., viscosity and colloid osmotic pressure) closely resembling those of plasma and are not toxic or antigenic. They do not contain haemoglobin, protein (except in gelatin solutions), antibodies or clotting factors and have only slight buffering effects. They may be given to recipients of any blood group. *Plasma substitutes may interfere with compatibility tests: a specimen of blood for this test should, therefore, always be collected before giving a plasma substitute.* Febrile and other forms of reaction may rarely attend the use of plasma substitutes.

Plasma substitutes are not substitutes for whole blood nor are they complete substitutes for plasma. They should, therefore, be used with discretion. Their main use is the restoration of a depleted blood volume when supplies of blood or plasma are lacking or inadequate. Plasma substitutes should not be given in such quantities that the haemoglobin concentration is reduced below 10·4 g. per cent. (70 per cent. Haldane) when resuscitation is complete. Plasma substitutes, particularly dextran, have been used successfully for the resuscitation of casualties with burns. It has been advised that, when large transfusions are needed in the treatment of such patients, the volume of plasma substitute transfused should not exceed the patient's calculated normal plasma volume. If the patient's transfusion requirements exceed this amount, the transfusion should be continued with plasma if available. If plasma is lacking the treatment should be continued with plasma substitute.

II. Storage of Blood and Plasma and Criteria of Fitness for Use

1. BLOOD

(i) Blood should not be used unless there is a clear line of demarcation between the sedimented cells and supernatant plasma, which should be straw coloured and free from visible signs of haemolysis. Haemolysis is shown by a reddish purple discoloration in the plasma immediately above the cell layer, which gradually spreads upwards. Fat may collect as a white layer on the surface of the plasma in some bottles: this is not a contra-indication to the use of the blood.

(ii) Time-expired blood must not be used.

(iii) *Storage:* Refrigerators selected for use as blood banks must be kept under constant supervision by a responsible member of the medical staff.

Normally the hospital pathologist should be in charge of the blood bank. **The blood bank refrigerator should not be used for the storage of food or pathological samples.**

The correct temperature for blood storage is 4°C.–6°C. (38°F.–42°F.). These limits must be rigidly observed. Ideally, the refrigerator should have an automatic temperature recording device and an alarm system; otherwise a maximum and minimum thermometer should be provided and the temperature recorded morning and evening in a book. Blood must never be allowed to freeze. Transfusion of blood which has been frozen and thawed may cause death.

An accurate record of issues of blood must be kept (see Section VI).

It is essential that bottles of blood should be stored constantly at a temperature of 4°C.–6°C. to preserve the red cells and prevent multiplication of chance bacterial contaminants.

Bottles of blood which have been removed from the refrigerator for more than one hour and not used, or bottles of blood which have been only partly used, should not be reserved for future use, but must be labelled "**DANGEROUS FOR PATIENTS**" and set aside in a special and clearly defined part of the refrigerator. Likewise, bottles which have been opened or punctured for sampling, if not used within 24 hours, should be similarly labelled although they have been stored at 4° C. since sampling.

Time-expired blood and blood unfit for use should be clearly segregated in the refrigerator from blood which may be used for transfusion. It should not be discarded but returned to the Regional Transfusion Centre and not allowed to accumulate.

Concentrated red cells must be used within 24 hours of preparation. The blood from which concentrated red cells are prepared should be as fresh as possible, and never older than 7 days.

2. Dried Plasma or Serum

(i) *Reconstitution of dried plasma or serum.* Each bottle issued is accompanied by a bottle containing 400 ml. non-pyrogenic sterile distilled water. Unscrew the caps of the bottle containing the water and the bottle of dried plasma/serum. If possible flame the tops of the bottles and pour the water into the bottle of dried plasma/serum and replace the cap at once. Solution is helped by gentle shaking and should be complete in 4–5 minutes. An opaque solution results due to lipoids in fine suspension. Dried plasma/serum is bottled in dry nitrogen and hermetically sealed. If the seal is damaged moisture may gain access to the plasma/serum and cause denaturation of the proteins, which reduces their solubility. If, after adding water, complete solution is delayed beyond 5–10 minutes, or if a gel forms, the bottle should not be used.

Reconstituted plasma/serum must be used without delay. If not used within 3 hours it should be discarded.

(ii) *Storage:* Dried plasma/serum should be stored in a cool, dry, dark place. Refrigeration is not necessary.

3. FLUID PLASMA

(i) Fluid plasma should not be used unless it is crystal clear. Cloudiness or deposits may be caused by bacterial contaminants and plasma showing these changes should be returned to the Regional Transfusion Centre.

(ii) *Storage:* Fluid plasma should be stored in a cool, dry, dark place. Refrigeration is not necessary.

4. PLASMA SUBSTITUTES

(i) Solutions of plasma substitute should not be used unless they are crystal clear and free from deposits.

(ii) *Storage:* Solutions of plasma substitute should be stored in a cool, dry, dark place. Refrigeration is not necessary.

III. Volume and Rate of Transfusion

Directions cannot be given dogmatically concerning the volume and rate of transfusion. The following factors must be considered—age of the patient, the general condition, the state of the circulatory system, and the indication for the transfusion. The young adult, with a normal myocardium, will tolerate the rapid infusion of relatively large quantities of protein fluid, even when the blood volume is normal. The chronically anaemic patient with an enfeebled myocardium, or those with respiratory or cardiac disorders, or infective and toxic conditions, on the other hand must be transfused very cautiously.

(1) In the presence of a severe injury accompanied by internal or external loss of blood, the rapid and adequate restoration of the blood volume is the immediate aim, and sufficient blood (or where sufficient blood is not available, plasma and blood in ratio 1 : 2) to raise the blood pressure to at least 100 mm.Hg. should be given. *In the previously healthy* patient, a rate of 100 ml./minute will usually be tolerated until the B.P. reaches 100 mm.Hg. Thereafter the rate must be slowed and the transfusion continued cautiously at a drip rate. Generally speaking, in the treatment of oligaemic shock only sufficient blood or plasma should be transfused to restore and maintain the systolic blood pressure at its normal level. *Therefore, the blood pressure should be recorded regularly throughout the transfusion and certainly at least after each bottle transfused.* For practical purposes the reliable guide to the quantity of fluid to transfuse is the patient's systolic blood pressure.

(2) In treating anaemia it may be assumed that one standard bottle of whole blood will raise the haemoglobin some 1·0g. per cent. (7 per cent. Haldane), and one standard bottle of concentrated red cells (the cells from 2 bottles of whole blood) will raise the haemoglobin some 2·0g. per cent. (15 per cent. Haldane). If the volume of whole blood required to raise the haemoglobin to the

chosen level exceeds one third of the calculated blood volume (40 ml./lb./ body weight), the transfusion should be given in two parts, separated by 2 days.

The rate of administration should not exceed 20–40 drops per minute, and in *chronic anaemias* with haemoglobin value of less than 3·7g. per cent. (25 per cent. Haldane), *cachexia, cardiac or respiratory disease*, this rate should be halved. The chosen rate of flow should be constantly and accurately maintained, and watch kept for cardiac embarrassment. (The venous pressure is a most valuable sign, and the state of filling of the jugular veins should be closely observed. The base of the lungs should be examined at frequent intervals for signs of pulmonary oedema.) Similar caution must be used in transfusing *septic* and *toxic patients.* A large volume of fluid, even slowly over a long period, should not be given to patients with these conditions: it should be divided and given slowly as a number of small transfusions.

Ideally, no major surgical procedure should be carried out unless the haemoglobin is at least 10·4*g. per cent.* (70 *per cent. Haldane*). Pre-operative transfusions for anaemia should be given an adequate time before operation to allow the full benefit of the transfusion to develop and to avoid the possibility of a reaction during operation.

IV. Blood Grouping and Compatibility Testing

In the interests of safety blood grouping and compatibility testing should only be performed by persons, whether doctors or technicians, who have had special instruction in modern techniques of such tests. Instruction in the techniques of blood grouping and compatibility testing can, if desired, be given at Regional Transfusion Centres. For these reasons no attempt is made to describe these techniques here.

Whatever form local arrangements may take, and whichever of the various recognised techniques of blood grouping and compatibility testing may be adopted, it is essential that a definite order of procedure be evolved and rigidly followed. The order of procedure, including details of techniques to be used, should be written out and be familiar not only to the laboratory staff but also to any members of the hospital staff who may have to perform blood grouping tests. The necessary pipettes, tubes, saline solutions etc., should always be kept in the same place. Antisera for use should (i) be labelled, (ii) be of adequate potency, (iii) have been subjected regularly and frequently to control tests and (iv) always be kept in the same place in the refrigerator.

There is no laboratory procedure in which the results of erroneous technique or interpretation are more disastrous than in the grouping and compatibility testing of blood. The result of a mistake may

be fatal. **The printed directions for carrying out these procedures are deceptively simple and give a false sense of security.** Special training and experience are essential if errors in grouping and compatibility testing are to be avoided.

No patient, except in grave emergency, should be given a blood transfusion unless

(*a*) the ABO and Rh groups of the patient's and donor's blood have been verified;

(*b*) a compatibility test between the patient's serum and the donor's red cells has been done.

Indiscriminate use of Group O blood is undesirable and may be dangerous because the serum of some Group O donors contains potent anti-A or anti-B antibodies which will destroy the recipient's red cells.

1. BLOOD SAMPLES

(i) *Adults and Children:* The ideal sample for blood grouping or compatibility testing is not less than 2 ml. of blood collected with a dry, sterile syringe, and put into a dry, sterile tube. Syringes kept in spirit or other antiseptic should not be used since sterilization may be imperfect and haemolysis may be caused by traces of antiseptic solutions. The needle should be removed from the syringe before the blood is expelled into the test tube, since haemolysis may be caused by the ejection of blood under pressure through a fine bore needle.

(ii) *Infants:* In infants at least 10–20 drops of blood, from a stab wound in the heel, avoiding the bone, made with a large needle, should be collected into a dry, sterile tube.

2. THE LANDSTEINER (ABO) BLOOD GROUPS: The constitution of the ABO group is:—

Blood Group	Approximate Frequency per cent. in Gt. Britain	Agglutinogen Content of Cells	Isoaglutinins present in Serum
AB	3·0	AB	None, i.e., neither anti-A nor anti-B
A	42·0	A	Anti-B
B	8·5	B	Anti-A
O	46·5	O (i.e., neither A nor B)	Anti-A and anti-B

Since Group A occurs almost as frequently as Group O it is wasteful as well as dangerous to use Group O blood irrespective of the recipient's blood group.

3. Rh BLOOD GROUPING: The Rh group of every person who is to receive a transfusion should be determined and, with certain exceptions, the blood of the appropriate Rh group should always be given (see Section IX). These tests may take 2–3 hours and should be performed only by experienced workers. If in doubt of the procedure to be followed in a particular case the hospital pathologist should be consulted.

4. COMPATIBILITY TESTS: Every blood transfusion should be preceded by a compatibility test, the data of which must be recorded. The request for this test should be sent to the laboratory as soon as possible after it has been decided to give a transfusion in order to avoid haste and to afford time for the repetition of tests should the results prove doubtful. The onus of ensuring that it is done should rest with the clinician who is to give the transfusion. A fresh sample of the recipient's serum must be obtained before each transfusion.

When delay may endanger life, a modified compatibility test can be done in 30–40 minutes, but the risk of errors is increased by doing tests hurriedly. If delay of this duration is too long, plasma, or a plasma substitute, should be given and, in the interim, grouping and compatibility tests should be done. *It is emphasised that in very few instances is the urgency so great that a compatibility test cannot be done.*

For some exceptional reason it may be considered that it is undesirable to give plasma, or a plasma substitute, while a compatibility test is done, and that blood must be transfused without such a test. Those in charge of blood banks should decide in advance, if necessary in consultation with the Regional Transfusion Director, the procedure to be followed in such exceptional circumstances.

If a compatibility test is not performed, 2–3 ml. of blood should be withdrawn immediately before giving the transfusion and sent to the laboratory for blood grouping.

All samples used for testing compatibility, or pre-transfusion samples, should be kept in the refrigerator (4° C.–6° C.) for not less than 2 days and preferably for at least 7 days after the transfusion since they may be needed for the investigation of reactions. [For a full consideration of blood grouping and compatibility testing see M.R.C. War Memorandum No. 9 and M.R.C. Memorandum No. 27.]

V. Administration of Transfusions

Practical instruction is essential. The following points are important:—

(1) Never fail to re-examine the bottle label before beginning transfusion. Incompatible transfusion disasters have occurred through neglect of this simple precaution. If a compatibility test has been made see that the full name, ward, and hospital number are on the label of the bottle of blood. When application is made for a compatibility test, the full name of the patient, his age, ward, hospital number (and the name of the hospital if the blood is being prepared at the Regional Transfusion Centre or in another hospital) and the transfusion and obstetric history should always be given on the application form.

Blood is labelled in the following colours:—

Group AB ...	white	Group B ...	pale red
Group A ...	yellow	Group O ...	blue

Labels on the bottles of Rh-negative blood bear also a vertical red bar.

(2) Do not heat blood or plasma before use. It is safe to transfuse blood cold from the refrigerator except under special circumstances, e.g., exchange transfusions in infants. If warming blood is necessary, the bottle should be placed in water the temperature of which does not exceed 40° C. The temperature should be measured with a thermometer. If blood is warmed the doctor who is to give the transfusion, or the sister-in-charge, should supervise the process. Blood which has been haemolysed by overheating may cause death.

(3) Do not leave blood out of the refrigerator for longer than 60 minutes. After that time it must be considered "**DANGEROUS FOR PATIENTS**", and so labelled.

(4) Do not reconstitute dried plasma until just before use.

(5) Most transfusions can be given by simple venepuncture. Select a vein in the forearm in preference to one in the antecubital fossa, especially with a restless patient, or during transport of a patient, since a needle in the antecubital fossa may be dislodged or driven through the vein, even when splinting is apparently secure, and precludes flexion of the elbow to the great discomfort of the patient.

(6) Do not cut down on a vein for it is hardly ever justifiable. If cannulation is unavoidable a vein in the leg, rather than one in the arm, should be used, except in patients undergoing abdominal operations. The internal saphenous vein is the most convenient. It is found one or two inches proximal to, and slightly lateral to, the internal malleolus on the subcutaneous surface of the tibia near the anterior border. *Never cut down on a vein in the antecubital fossa.*

(7) Apply pressure with a tourniquet or a sphygmomanometer cuff (50–60 mm. Hg.) round the upper part of the limb to distend the veins.

(8) Employ palpation as well as inspection in selecting a vein. After sterilizing the skin inject a little local anaesthetic (0·25 ml.) intradermally over the selected vein and leave it for ½–1 minute to take effect.

(9) Connect the transfusion apparatus with the bottle and see that it is in working order before the transfusion. First the clip should be tightly clamped on the distal length of rubber tubing a few inches from the needle mount, and the rubber bung inserted in the bottle. When using the " piercing needle type " of set, the short piercing needle should be pushed through one segment of the rubber closure marked " 2 ". The long piercing needle, which serves as the air inlet, should then be thrust through the other segment marked " 2 ". (During this manoeuvre the rubber tubing attached to this needle should be occluded and kept occluded while the bottle is being suspended, and the tubing attached to the side of the bottle.) The bottle should then be suspended at a height of 3–4 feet above the site of venepuncture. Let the rubber tubing, etc., hang full length; then hold the distal length of rubber tubing up in a U so that the distal end does not come above the level of the drip counter. This procedure is important if " flooding " of the drip counter is to be avoided. Slowly open the clip and allow the blood to expel all the air from the distal tubing.

To avoid spilling blood through the glass air-inlet tube of the bung type of set when the bottle is inverted to be suspended, a small sterile cork (provided in the set) is inserted in this tube. The cork must be removed after the bottle is suspended, otherwise the blood will not flow when the screw clip is released.

(10) Introduce the needle into the vein, release the tourniquet and fix the needle and rubber tubing securely in position with adhesive strapping in such a way that no pull is exerted on the needle.

(11) See that the patient is comfortable and that the arm or leg is suitably placed on a pillow if necessary, and is kept warm during transfusion. Splinting may be advisable, and is usually necessary if the patient is to be moved, or is restless or unco-operative.

(12) The patient should be watched closely during the first 30 minutes of a transfusion in order (*a*) to see that the desired rate of flow is in fact maintained and (*b*) to observe whether any untoward reaction occurs.

(13) When the transfusion is completed, return the **UNWASHED** bottle or bottles, whether they have contained blood or plasma, to the refrigerator for 48 hours. In the event of some complication, e.g., haemoglobinuria or jaundice following transfusion, a sample of the fluid given will then be available for investigation. If no complication has occurred after 2 days, the bottle or bottles may

be washed. **WASH THE SET IMMEDIATELY** by flushing with cold tap water from another transfusion bottle.

(14) If the transfusion stops inspect the set to see that the tubing is not kinked. Adjust the screw clamp. Inspect the position of the needle and manipulate it gently. If these simple manoeuvres do not re-establish the flow, close the screw clamp and disconnect the set from the needle. Test the patency of the needle by gentle suction with a sterile syringe filled with sterile saline solution; do not try to inject saline through the needle. Test the patency of the set by releasing the screw clamp. If either the needle or the set is blocked, a fresh needle or set should be substituted. Do not try to clear the obstruction by applying positive pressure in the transfusion bottle.

VI. Transfusion Records

1. A record of every transfusion should be made in the patient's case notes AND on the special card or form (N.B.T.S. 11) attached to the bottle.

Such records should show:—

(i) *Serial number of bottles of blood and plasma.* The recording of these numbers must never be omitted since they may be the only means of tracing and checking a donor's blood if there is any question of incompatible transfusion, or homologous serum jaundice. In the latter instance it is not only important to be able to trace the donor bearing the infective agent, but also to be able to trace and withdraw other bottles of the same icterogenic batches of plasma or serum. Only by the careful and invariable recording of serial numbers on bottles of transfusion fluid can this be accomplished. All cases of homologous serum jaundice, suspect or proven, should be reported immediately to the Regional Transfusion Director. The necessity of accurate recording is still not fully appreciated.

(ii) In transfusions for anaemia: the pulse rate recorded half-hourly, and the temperature recorded hourly, throughout transfusion and for four hours afterwards.

(iii) In transfusions for oligaemic shock: the pulse rate and blood pressure recorded at the commencement of transfusion and after each bottle of fluid transfused.

(iv) The time taken to give the transfusion.

(v) Results of urine analysis. As a routine the urine voided before every transfusion, and any urine voided during the transfusion and in the 24 hours afterwards should be tested (colour, albumin test and examination of sediment). The reason for this is that the donor's blood may be abnormally rapidly destroyed and haemoglobinuria may occur, perhaps only once, and may be

the sole evidence of this destruction. It is therefore important to examine all urine voided during and after transfusion.

(vi) Particulars of any immediate reactions to transfusion (for classification see below under " Complications and Dangers of Transfusion ").

2. Every hospital should keep records showing the following details of all transfusions of blood and plasma. Whenever possible the hospital transfusion officer should keep this record; in hospitals having no transfusion officer it should be the duty of a responsible person, preferably the pathologist.

The blood bank register should show:—

(i) Date and time of removal of the blood from the blood bank.

(ii) Name of person fetching the blood from the blood bank.

(iii) Full name, ward, and hospital number of recipient.

(iv) Blood group (ABO and Rh) of recipient.

(v) By whom compatibility test was performed.

(vi) Serial number and blood group (ABO and Rh) and date of collection of each bottle of blood transfused: (or the serial number of each bottle of plasma used).

(vii) Clinical condition necessitating transfusion.

(viii) Reactions, stating—

(*a*) their nature;

(*b*) whether patient had a history of miscarriage, still birth, hydropic, anaemic or jaundiced babies, or has had previous transfusions, or injections of blood or plasma.

(ix) Name of doctor giving the transfusion.

The plasma register should contain the same information with the omission of (iv) and (v).

VII. Complications and Dangers of Transfusion

1 Febrile Reactions:

Classification. Grade 1. Rise of temperature to 100° F.;

Grade 2. Rise of temperature above 100° F. with sensation of chill but no actual shivering;

Grade 3. Rigor — with or without other symptoms.

The significance of a febrile reaction depends upon the cause. A febrile reaction during transfusion is an indication for stopping the transfusion. Fluctuations in temperature due to the patient's disease must be distinguished from febrile reactions due to transfusion.

2. CIRCULATORY OVERLOADING AND PULMONARY OEDEMA: The danger of circulatory overloading exists in patients with heart disease, chronic anaemia and cachectic states, severe sepsis, toxaemia, etc., in babies and in aged persons. The risk will obtain if transfusion is too rapid or if the quantity of fluid transfused is too great for the particular case. Circulatory overloading can be avoided by slow drip transfusion and avoidance of transfusion of excessive quantities. The ideal material for severe anaemic states is concentrated red cells.

3. HAEMOLYSIS IN TRANSFUSION: The haemolytic reaction due to incompatible transfusion is avoided by transfusing strictly homologous blood, i.e., blood of the same ABO and Rh (D antigen) groups as those of the recipient, which has been subjected to a compatibility test. Group O blood should not be used indiscriminately since the antibodies in the blood of certain Group O donors are sufficiently potent to destroy the red cells of a Group AB, A, or B recipient. Very occasionally the same may obtain when Group A or B blood is given to a Group AB recipient.

A haemolytic reaction, similar to that following the transfusion of incompatible blood may follow the transfusion of out-dated blood, or blood which has been haemolysed by freezing, overheating or infection.

The symptoms of a haemolytic reaction vary from case to case. Usually there is a rapidly developing febrile reaction, sometimes after as little as a few ml. of blood have been given, accompanied by dyspnoea, intense headache, a feeling of constriction of the chest, and pain, sometimes intense, in the lumbar region. The reaction usually occurs during or immediately after transfusion but signs and symptoms may not appear for some hours. None may be apparent in the unconscious or anaesthetised patient. Haemoglobinuria and jaundice may occur. Several hours will usually elapse before the onset of jaundice and it may be delayed for a few days. Haemoglobinuria is usually transient. Acute cardiac failure or suppression of urine is the usual cause of death.

Treatment of haemolysis following transfusion: When haemolysis following transfusion, due to incompatibility or any other cause, is suspected the transfusion should be stopped immediately and expert advice should be obtained. Treatment should be based on the principle of assisting the renal excretion of haemoglobin where this is possible, but it is important to appreciate that the patient's kidney function may have been so impaired by the haemolytic reaction that the secretion of adequate amounts of urine is temporarily not possible. With correct management, avoidance of sodium and water-overload, etc., the patient can be tided over this phase of renal failure and restoration of kidney function may be expected, within 7–21 days in most cases. While awaiting expert advice therefore, the following treatment may be instituted. (The quantities are suitable for the average adult weighing 10 stones and should, if necessary, be adjusted.)

(i) If the patient shows signs of oligaemic shock, steps must be taken immediately to restore the general circulation by transfusion of compatible blood, plasma, or a plasma substitute. Delay increases the risk of renal damage.

(ii) If fluids can be taken by mouth, 1 litre of water should be given within a period of half to one hour.

(iii) If fluids cannot be taken by mouth, 1,000 ml. of 5 or 10 per cent. glucose in distilled water should be infused intravenously.

(iv) A fluid balance chart must be kept.

In the absence of a satisfactory urinary output following these measures no further attempts should be made to promote a water diuresis. The case must be recognised as one of renal failure and, for a considerable period, the intake of salt and water must be limited strictly to that necessary to cover renal and extra-renal losses only. In addition, an adequate calorie intake should be secured to limit tissue protein breakdown and the consequent liberation of potassium.

These requirements can be accomplished through a regime evolved by Bull and his colleagues (Lancet, 1949, ii, 229), in which the following mixture is administered through a polythene stomach tube (the mixture being too nauseating to be taken by mouth): Dextrose 400 g., Peanut Oil 100 g., Acacia q.s. to emulsify, Water to 1 litre. One litre of this mixture, which will provide 2,500 calories and sufficient water to cover the patient's loss of water through the skin and lungs, is dripped slowly into the stomach during each period of 24 hours. The volume of any urine passed should be measured and an equivalent volume of fluid of the following composition added to the basic intake to cover the urinary loss of water and electrolytes:

NaCl ... 3·5 g.
$NaHCO_3$ ... 1·0 g.
Water to 1 litre.

Should the patient vomit, water and electrolyte loss via this route is prevented by collecting the vomitus, filtering it through lint and returning it via the stomach tube.

This regime should be continued until the phase of oliguria is succeeded by one of diuresis. This may be delayed for 7–21 days, and experience has shown that the onset of the diuresis cannot be hastened by drastic procedures such as renal decapsulation or splanchnic block, which are unjustifiable and dangerous. The use of artificial kidney procedures, or peritoneal dialysis, are not required unless the above treatment was not begun for several days after the onset of anuria and the patient's serum potassium has risen to a dangerously high level. It is essential from the onset to maintain a good circulation and oxygen supply to the damaged

kidneys and if the patient is anaemic the haemoglobin should be raised to at least 70 per cent. (10·4 g.) by the transfusion of concentrated red cells.

The regime outlined above should be continued for 2 days after a diuresis exceeding 1 litre per day has occurred. The patient has now passed into the early diuretic phase during which large quantities of water and electrolytes may be lost. This phase will persist for as many days after 1 litre of urine has been passed as there were days of oliguria before it, and during this time careful control of water and mineral balance must be continued. The synthetic diet should now be replaced by an oral diet of low protein content, basically fruit and fruit juices.

Mineral losses can be estimated by examination of the urine but it is usually safe to assume that the urine has a composition approaching that of half isotonic extracellular fluid. Therefore the diet should provide:—

(*a*) 1 litre of water to balance insensible loss;
(*b*) a volume of water equal to the urine volume;
(*c*) 3·5 g. NaCl, 1·0 g. $NaHCO_3$ } per litre of urine passed.

4. EMBOLISM:

(i) Air Embolism: Positive pressure is sometimes applied to the transfusion fluid by attaching a bellows, e.g., a Higginson's syringe, to the air inlet tube. This manoeuvre is seldom necessary except when resuscitating patients or casualties with severe oligaemic shock. Rapid transfusion can also be achieved without positive pressure by using a 24/10 gauge needle in place of the usual 15/10 gauge giving needle.

If positive pressure is used the transfusion must be continuously supervised by a doctor who understands the dangers, and the pressure must NEVER be continued after the bottle is three-quarters empty. Positive pressure must never be used to overcome an obstruction in the giving set. If the lower part of the filter (in the bottle) has become blocked, and the level of blood has fallen sufficiently low, air may be forced into the giving set; or clots may be forced through the needle into the circulation.

Air embolism may also result from leaks or faults in the apparatus, or from faulty cannulation of a vein.

(ii) Liquid plasma should not be used if it contains particles of fibrin since these may cause embolism.

5. ALLERGIC REACTIONS: Skin rashes, urticarial weals and angio-neurotic oedema may complicate transfusion. Treatment is with adrenaline, anti-histamine products, etc., and de-sensitisation may be necessary.

6. TRANSMISSION OF INFECTION: Never leave blood out of cold storage longer than 60 minutes. Breaks in refrigeration may allow chance contaminating bacteria to multiply and such blood may

cause a severe or even fatal reaction. Wear a mask when uncapping the transfusion bottle. Blood issued by Regional Transfusion Centres to banks is subjected to a syphilis test. When blood is taken from a donor and transfused immediately, i.e.. fresh as opposed to stored blood, it is the *responsibility of the physician* to ensure that the donor is free from syphilis, or other transmissible disease.

7. HOMOLOGOUS SERUM JAUNDICE: This complication is a risk attaching to the use of whole blood and plasma, and certain plasma fractions (thrombin, fibrinogen). As far as is known the case incidence is:—

(i) after transfusion of whole blood ... about 0·8 per cent.
(ii) after transfusion of small pool dried plasma ... ... about 1·5 per cent.

Only a few instances of jaundice following the use of fibrinogen and thrombin are on record.

It is clear from the above figures that the use of massive transfusions of blood (10 or more bottles) will carry much the same risk of transmitting jaundice as the transfusion of one bottle of small pool plasma which is made from 10 blood donations.

Homologous serum jaundice is clinically indistinguishable from infective hepatitis and occurs 40–150 days after transfusion. It is thought to be caused by a virus.

Serial numbers of bottles of blood or plasma used for transfusion should invariably be recorded in the case notes (see p. 12). If several bottles of plasma are to be given to one patient they should be of the same batch in order to reduce the risk of transmitting jaundice.

Cases of homologous serum jaundice, together with the serial numbers of the bottles of blood or plasma involved must, as already recommended, be reported immediately to the Regional Transfusion Director so that he can arrange to investigate the donors and to withdraw any plasma of the same batch which may remain unused.

VIII. Investigation of Transfusion Reactions

In the event of a severe reaction occurring the Regional Transfusion Director should be notified. The following specimens are needed, initially, to make an investigation:—

(1) The blood samples used for the compatibility test before transfusion, or the pre-transfusion sample (see Section IV, Compatibility Tests). Such samples should be kept for not less than 2 days in the refrigerator.
(2) The remains of blood or plasma in the bottle or bottles, used for transfusion. (All bottles of blood or plasma used for transfusion should be kept in the refrigerator

(4° C.–6° C.) for 48 hours after use lest investigations prove necessary. After the lapse of this time they should be washed).

(3) A 10–20 ml. sample of blood from the patient collected into a dry, sterile tube with a dry, sterile syringe 3 hours after the reaction. Put about 2 ml. into an oxalated tube and the remainder into a dry, sterile tube.

(4) A clean sample of urine. All urine voided for 2 or 3 days should be measured and examined; abnormally coloured urine should be conserved for investigation.

Most haemolytic reactions are accompanied by haemoglobinaemia or hyperbilirubinaemia, or both, but these phenomena will depend upon the rate of destruction and elimination of the transfused blood, upon the rate at which the blood is given, and when the sample is taken. Examination of a sample of blood for these features is often the quickest way to decide whether a reaction is or is not haemolytic. If the observed rise of haemoglobin concentration does not approximate to the expected rise and no obvious cause, e.g., haemorrhage, can be found, the possibility of a haemolytic reaction, the so-called " silent " or " inapparent reaction ", should be considered.

IX. The Rh Factor

The Rh group of a recipient should always be determined since about 50 per cent. of Rh-negative recipients, irrespective of their sex, may be immunised by the Rh factor if given transfusions of Rh-positive blood. A proportion of Rh-negative mothers may become immunised by the Rh factor during pregnancy by bearing Rh-positive foetuses, the latter inheriting the Rh factor from the father. Any of these immunised persons will, if transfused with Rh-positive blood, respond by destroying the donor's blood. A fatal haemolytic reaction may occur. Moreover, a single transfusion may so sensitize a female to the Rh antigen that any subsequent Rh-positive offspring may be affected with haemolytic disease in the severest forms.

All persons, whatever their age, should be transfused only with Rh compatible blood except in grave emergencies in which there is not time to determine the Rh group. In such cases Rh-negative blood may be given and, if this is not available, plasma or serum may be used.

If for any exceptional reason Rh-positive blood has been given to a patient of unknown Rh group, the pre-transfusion sample should be submitted for Rh grouping without delay.

Infants suffering from haemolytic disease of the new born, due to rhesus immunisation of an Rh-negative mother, should be transfused with Rh-negative blood though the infant itself is Rh-positive. (For a full consideration of the Rhesus Factor see M.R.C. Memorandum No. 27, 1952).

(21974) Wt. 30018—8909 22m 1/54 D.L./HE/7


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