

BLOOD TRANSFUSION

Principles of Management and Operation
of a Blood Transfusion Service

HOWARD A. MAYGROCK

President, American Association of Blood Banks
President, International Society of Blood Transfusion
President, American Red Cross Society



Publication

SNBTS DOCUMENT REQUEST No:

2010/00056

BLOOD TRANSFUSION

*A Guide to the Formation and Operation
of a Transfusion Service*

Edited by

C. C. BOWLEY, K. L. G. GOLDSMITH & W. D'A. MAYCOCK

on behalf of

the World Health Organization, the International Society
of Blood Transfusion, and the League of Red Cross Societies



WORLD HEALTH ORGANIZATION

GENEVA

1971

© World Health Organization 1971

Publications of the World Health Organization enjoy copyright protection in accordance with the provisions of Protocol 2 of the Universal Copyright Convention. Nevertheless governmental agencies or learned and professional societies may reproduce data or excerpts or illustrations from them without requesting an authorization from the World Health Organization.

For rights of reproduction or translation of WHO publications *in toto*, application should be made to the Office of Publications and Translation, World Health Organization, Geneva, Switzerland. The World Health Organization welcomes such applications.

The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by the World Health Organization in preference to others of a similar nature which are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

PRINTED IN SWITZERLAND

CONTENTS

	Page
Preface	7
Introduction: Organization of a national blood transfusion service . .	9
 PART I: RECRUITMENT AND SELECTION OF BLOOD DONORS — MAINTENANCE OF DONOR RECORDS	
Chapter 1. Recruitment of blood donors	15
Chapter 2. Possible complications of blood donation and diseases trans- missible by transfusion	21
Chapter 3. Selection and medical examination of donors	29
Chapter 4. Donor records	33
 PART II: CENTRAL ORGANIZATION — THE PREPARATION OF EQUIPMENT	
Chapter 5. Staffing and accommodation	41
Chapter 6. Preparation of containers, closures, and anticoagulants . .	45
Chapter 7. Preparation of taking and giving sets.	55
 PART III: BLOOD COLLECTION AND STORAGE	
Chapter 8. Conduct of a donor session	65
Chapter 9. Storage and transport of blood	70
 PART IV: LABORATORY ORGANIZATION AND TECHNIQUES	
Chapter 10. Organization and management of a blood bank	75
Chapter 11. Grouping techniques (ABO and Rh)	78
Chapter 12. Screening of donor blood for unwanted antibodies . . .	87
Chapter 13. Compatibility tests	89
Chapter 14. Detection and identification of irregular antibodies using a standard red cell panel	94
Chapter 15. Preservation of red cells for grouping	97
Chapter 16. Cleaning laboratory glassware	99
Chapter 17. Preparation of grouping sera	100
Chapter 18. Laboratory documentation.	106
Chapter 19. Laboratory staff and equipment	111
Chapter 20. Investigation of transfusion reactions	115
Chapter 21. Prenatal and postnatal serology	118
Chapter 22. Auto-immune acquired haemolytic anaemia	121
Chapter 23. Basic techniques	122
References	131

Preface

In many developing countries, blood transfusion services are still insufficiently organized or wholly lacking. This situation is mainly due to a great shortage of the qualified staff, both professional and technical, needed to create and develop such services where resources and equipment may be unavoidably restricted.

The present book is intended to help physicians and pathologists who, after receiving a basic training in blood transfusion, are entrusted with the responsibility of establishing and developing transfusion services in their own countries, either under the ministry of health or through the agency of a voluntary organization, such as a national Red Cross Society. It provides practical information on the four main aspects of blood transfusion: organization of a service; recruitment of donors; collection, preservation, and distribution of blood; and laboratory techniques.

The World Health Organization, the International Society of Blood Transfusion, and the League of Red Cross Societies have given constant support to the preparation of this guide and have reviewed the final manuscript. This was prepared by Dr C. C. Bowley in collaboration with Dr K. L. G. Goldsmith, under the general guidance of Dr W. d'A. Maycock, on the basis of contributions received from the directors of Red Cross and other national transfusion services. A full list of contributors is given on page 8.

CONTRIBUTORS

Dr C. C. BOWLEY, Director, National Blood Transfusion Service,
Regional Transfusion Centre, Sheffield, England

Dr K. L. G. GOLDSMITH, Director, WHO International Blood
Group Reference Laboratory, Medical Research Council's
Blood Group Reference Laboratory, London, England

Professor A. HÄSSIG, Director, Central Laboratory, Swiss Red
Cross Blood Transfusion Service, Berne, Switzerland

Dr R. HEIZ, Institute of Serum Therapy, Berne, Switzerland

Professor J. J. VAN LOGHEM, Director, Central Laboratory, Nether-
lands Red Cross Blood Transfusion Service, Amsterdam,
Netherlands]

The late Mr R. J. G. MCCRUDDEN, formerly Regional Donor
Organizer, National Blood Transfusion Service, South-West
Regional Transfusion Centre, Bristol, England

Dr W. d'A. MAYCOCK, Head, Blood Products Laboratory, Lister
Institute of Preventive Medicine, Elstree, England

Dr G. MILLER, National Director, Canadian Red Cross Blood
Transfusion Service, Toronto, Canada

Professor J. P. SOULIER, Director-General, National Blood Trans-
fusion Centre, Paris, France

Dr K. STAMPELI, Chief, Medical Service, Central Laboratory,
Swiss Red Cross Blood Transfusion Service, Berne, Switzerland

INTRODUCTION

Organization of a National Blood Transfusion Service

The primary task of a national blood transfusion service is to meet the country's needs for blood and blood derivatives. This entails co-operation with the public health authorities, hospitals, and medical associations and the promotion of good relationships with the general public.

A national blood transfusion service cannot be built up quickly. Its development is a laborious and lengthy task which will be successful only if there is, from the beginning, a clearly defined organizational structure and complete agreement about the responsibilities allotted to each organization or group participating in the enterprise. Depending upon national policy, the country's ministry of health may assume responsibility for organizing and administering the transfusion service at all levels or may delegate some or all of the responsibility to a suitable organization such as the national Red Cross Society.

The introduction of a national blood transfusion service where none exists should preferably be accompanied or preceded by the establishment of a national transfusion committee, whose task will be to co-ordinate the programme at a national level. Membership of this body should include representatives of the public health authorities, the medical services of the armed forces, national Red Cross, Red Crescent, or Red Lion and Sun Societies, and the leading medical faculties, as well as individual experts interested in blood transfusion.

The first task of the transfusion committee will be to appoint, as director of the national blood transfusion service, a suitably qualified medical practitioner with the necessary experience to implement the committee's policy.

The first task of the director is to assess the transfusion needs of the country and to advise the committee on how best they can be met.

To implement its agreed policy, the committee must first establish a centre where both organizational and technical matters relating to blood transfusion are co-ordinated for the whole country. Initially this may be established within an existing unit of the health laboratory service. This centre will be placed under the director of the national blood transfusion service and will function, in the early stages, as a regional transfusion centre.

The responsibilities of a regional transfusion centre are :

- (a) the recruitment of blood donors and the maintenance of donor records ;
- (b) the medical examination of donors and the collection of blood ;
- (c) the preparation and distribution of transfusion equipment ;
- (d) the testing, storage, and distribution of donated blood ;
- (e) the examination of special blood samples—for example, from suspected transfusion reactions or possible cases of haemolytic disease of the newborn.

In view of the increasing complexity of antibody identification, the examination of prenatal blood samples and the determination of blood genotypes, when indicated, are also particularly appropriate work for a regional transfusion centre and materially assist in obtaining antisera, but this development may have to come after the more immediate objective of providing blood for transfusion has been achieved.

These tasks are extensive and may be undertaken step by step.

Similar regional transfusion centres can gradually be established as necessary for other areas, the staff receiving their preliminary training at the original centre which, in the natural course of development, will eventually become recognized as the national reference centre for transfusion problems. At some stage it may be necessary for the director and co-ordinator of the national transfusion service, while retaining these functions, to hand over responsibility for the centre to another director.

A national reference centre for transfusion problems would have the following additional duties :

- (a) to issue directions or recommendations on matters of organization, equipment, or technique pertaining to blood transfusion ;
- (b) to co-ordinate and supervise the activity of regional blood transfusion centres in order to carry out the policy decisions of the national transfusion committee ;
- (c) to undertake blood group serological examinations of specimens referred from regional transfusion centres because of their particular difficulty or significance ;
- (d) to manufacture and distribute stable blood derivatives (dried plasma, plasma fractions) and diagnostic reagents (blood grouping test sera) ;
- (e) to collect rare sera from other laboratories and act as a central distribution point for them ;
- (f) to train doctors and medical auxiliary personnel (e.g., technicians) from the regional transfusion centres and other postgraduate students in the

INTRODUCTION

11

more advanced aspects of blood group serology and blood transfusion organization ;

(g) to institute and maintain a national panel of blood donors of rare groups ; and

(h) to maintain contact with national reference laboratories in other countries in order to keep abreast of recent developments and facilitate the exchange of sera.

In some circumstances the reference centre might also undertake the preparation and distribution of equipment (containers, taking and giving sets) to regional transfusion centres, but this would depend on local circumstances.

The director and co-ordinator of the national transfusion service might wish to retain control of the reference work, in which circumstances he and the director of the regional transfusion centre would work in close co-operation, so that the reference centre would remain in close contact with daily problems in the field and thus be in less danger of issuing instructions or recommendations relating only partially, or not at all, to practical conditions.

Finally, one of the service's laboratories would be designated by the commission as the national blood group reference laboratory, which, after recognition by WHO, would collaborate with other national blood group reference laboratories and with the WHO International Blood Group Reference Laboratory, Medical Research Council's Blood Group Reference Laboratory, London, England.

During the development of the service and its specialized units, it will become necessary to provide separate accommodation with appropriate services and equipment for the work involved. The following chapters describe the basic work of a transfusion service and contain further suggestions for organizing a national blood transfusion service and regional transfusion centres.

PART I

RECRUITMENT AND SELECTION OF BLOOD DONORS
MAINTENANCE OF DONOR RECORDS

CHAPTER 1

Recruitment of Blood Donors

Basic systems

There are three basic systems of obtaining blood donors: (a) paid donation; (b) the bank system; and (c) voluntary unpaid donation.

Paid donation

Under the paid donation system the donor receives financial recompense. The transfusion service is thereby relieved of some responsibility towards the donor, and may sell the blood and blood derivatives to a hospital or to the recipient at a profit. Apart from the disadvantage of commercializing so precious a product as human blood, the system may lead to too frequent donation. In the absence of careful medical supervision this will result in damage to health from anaemia and hypoproteinaemia, especially as paid donors are often already in poor health and may show nutritional and other deficiencies. Moreover, there is a danger that donors in need of money will conceal previous illnesses, such as jaundice. Added to this, "professional" donors may form syndicates and from time to time demand an increase in financial recompense. This, together with the indisputable fact that such donors mostly come from the lowest social strata where alcoholics and drug addicts are often found, has brought paid blood donation into disrepute in many places.

Bank system

Under the so-called bank system, donors are recruited by the recipient himself, who has to pay if he is unable to replace the blood he needs by donations from his family, relatives, or friends. In this system, high transfusion fees provide the incentive for donor recruitment; it works, therefore, only where the patient has to bear the costs of treatment himself. If this is not the case, if for example the expenses are born by a sickness insurance company or a state health service, then the stimulus to recruit donors will be lacking. The credit principle entails an exceptionally heavy administrative burden, since complicated calculations involving different blood banks have to be made. The bank system has also been organized on a community basis. For example, workers at a certain factory and their

immediate dependents are entitled to free blood transfusion only as long as donor sessions at the factory maintain a credit balance. This system originated, and is still widely prevalent, in the USA, where regional and national clearing houses have been set up to settle the accounts involved.

Voluntary unpaid donation

The voluntary unpaid blood donation is a humanitarian act towards the sick by the healthy. A blood transfusion service based upon unpaid donations is obliged to work on a non-profit basis, since blood given free of charge should not be used for profit. If the service is not subsidized by the state, it may charge the patients, the hospitals, or their sickness insurance companies, but only for the costs of storing, distributing, or processing blood and blood derivatives. Any surplus funds accruing from such charges should be used only to improve or extend the service, not for other purposes. Under this system it is easier to verify the donor's state of health, since—unlike some paid donors—he has no reason to try to conceal illness.

At the XVIIth International Conference of the Red Cross in Stockholm in 1948 a resolution was adopted recommending the voluntary free gift of blood as the ideal system. Since then its obvious advantages have everywhere brought good results. In a number of countries the blood transfusion services have successfully changed over from the paid system to that of free donation.

It is most strongly recommended that new transfusion services should make every effort to adopt the voluntary unpaid system from the beginning.

Size of donor panel

In countries with modern health services and extensive blood transfusion services, it is possible to arrive at an approximation of the amount of blood used each year in terms of the number of hospital beds. The figure should be based on the number of emergency beds in general hospitals, i.e., it should exclude beds for infectious diseases, chronic sickness, mental deficiency, and mental illness, and pre-convalescence and convalescence. The following is a representative example:

<i>England and Wales (1969)</i>	<i>Units issued per emergency bed</i>
Whole human blood:	6.76
Plasma:	0.42

Estimates linked to the number of hospital beds may be misleading as they cannot take the number of patients treated into account. More or fewer patients may occupy the same number of beds a year, depending upon the effectiveness of treatment, the efficiency of the hospital, the

RECRUITMENT OF BLOOD DONORS

17

diseases involved, and other factors. It is therefore more realistic to base estimates of need upon the number of patients treated in a year.

A convenient figure to use is the number of patients discharged or dying in a year. Thus :

<i>England and Wales (1969)</i>	<i>Units issued per 100 patients discharged or dying</i>
Blood :	24.66
Plasma :	1.55

A record of the number of patients discharged or dying however is less likely to be available than the number of beds.

In the United Kingdom the unpaid donor system is used. It is national policy to ask for donations twice a year, at approximately six-monthly intervals. The national donor response rate varies from time to time and place to place; the average is between 50% and 55%. About 7% of donors reporting at blood collecting sessions are deferred on medical grounds, usually in their own interests rather than those of the potential recipients.

Assuming similar conditions elsewhere, it may be said that to meet the blood requirements of 1000 emergency hospital beds a panel of about 7000 donors is required. Experience has shown, however, that these figures are applicable only after a service has been operating for five to ten years, and the initial activities need not be on such a large scale. A frequently quoted estimate is that, in countries with fully operational public health and blood transfusion services, the need for blood can be met if about 2% of the population are regular donors. With the development of open heart surgery, renal dialysis, and other procedures using transfusion, it is probable that this figure is now too low.

Recruiting methods

Philanthropic organizations, such as national Red Cross Societies, can be very helpful in recruiting donors. It is unwise, however, to separate the recruitment and care of donors from the medical and technical services in the regional transfusion centre. All belong under the same roof and should come under the responsibility of the medical director of the centre. The donor organizer and his staff, responsible to the medical director for donor recruitment and care, will be able to carry out their work usefully and correctly only if they are constantly aware of the centre's needs. Similarly, the medical director must be constantly aware of the problems of donor recruitment and care. The motto of the medical director should be : "Without the donor panel there would be no blood transfusion service ;

therefore the convenience, comfort, and wishes of the donors should be given every consideration." For the donor organizer the motto should be: "The blood must be available in the quantity needed, at the place and time required. All other considerations are subservient to this."

Initial steps to form a panel of donors are best taken within such groups and communities as the armed forces, the police, large industrial or commercial undertakings, universities, prisons, and social or religious foundations. The advantages are that information about the need for donors and the speed and ease of donation can easily be given directly to the members of the community or group in question and that blood collection can be arranged and carried out without delay. It is also possible to introduce a competitive atmosphere in which public comparisons of the results of blood collections will encourage more donors to come forward. Success is more likely in a community if the leaders set a good example.

It is of primary importance to dispel donors' fears at the outset. If a new donor is bled skilfully, treated well, and convinced by personal experience that blood donation is harmless, he will usually return to make further donations. This is the best advertisement for blood donation. If donor recruitment in groups or communities meets with difficulty in the initial stages of the service, it may be stimulated by arranging some small advantage for the donors, such as additional free time for soldiers, policemen, or factory workers, but this is not generally necessary. The fact that the management allows the donor session, usually in its premises during working hours, is normally sufficient encouragement. Financial remuneration should be avoided in all circumstances.

Recruitment among the general public may be started once experience has been gained with special groups or organizations. Apart from local publicity to pave the way for the opening of large blood donor clinics, general information must be given regularly to the public through modern information media, i.e., the press, radio, films, and television. General articles on the meaning of blood donation and reports on donor clinics should be placed in newspapers. Material on dramatic blood transfusions must be handled very carefully by experienced publicity officers as many newspaper editors are unwilling to publish an account of something that has already happened and is therefore no longer news; on the other hand journalists with advance information have been known to violate the privacy of both donor and recipient in a totally unacceptable manner. While it is essential to maintain good relations with the press it is usually inadvisable to release personal details about either donors or patients. Radio and television are suitable for urgent appeals and information on blood donation, which should always be based on actual fact if the public is to feel personally involved. Advertising to impart general information about the existence and work of the service may, however, be ineffective, if it is not followed up by an intensive local campaign.

In addition to such general publicity, specific local recruiting propaganda is needed. Local publicity is particularly effective if carried out in close co-operation with associations willing to adopt blood donation as one of their interests. The Red Cross and other philanthropic and civic organizations can render especially valuable service at the local level. At meetings of such organizations, lectures on transfusion, illustrated by films, can be very effective, particularly if they are given by doctors well-known to the audience. Propaganda pamphlets containing enrolment forms should be distributed on these occasions. Great assistance in recruiting donors can be given by public figures—magistrates, religious and political leaders, film stars, and sportsmen—if they are prepared to volunteer as donors and allow their example to be made public.

The decisive factor in the success of a transfusion service is that as many people as possible should become regular donors after their first donation. They must therefore be treated with every consideration during donation; waiting periods must be kept short; venepuncture must be perfect. If venepuncture on a new donor is unsatisfactory it should not be repeated in the other arm. Very occasionally a regular donor may be upset if less than a full donation is obtained for technical reasons; only in such a case and at the donor's request, should a second venepuncture be considered. Attractive light refreshments should await the donor in a bright, clean, and pleasant room, and above all the staff must at all times appear courteous, interested, and cheerful. The donor must be thanked for his donation. A thank-you card or badge given after the first donation is usually appreciated and is effective in encouraging donors to return. The possibility of earning a badge after a given number of donations is also effective; for example, a bronze badge could be awarded for 5-10 donations, a silver one for 15-25 donations, and a gold or silver gilt one for 30-50 donations.

The anonymity of donor and recipient should always be preserved. Although telling a donor how his blood has been used might help to retain his interest, it is most unwise to institute this practice because it will be increasingly difficult and finally impossible to continue it as the transfusion service grows. There might also be occasions on which it would be embarrassing to the service to inform the donor of the use made of his blood. It is preferable to tell donors about the use of blood and other aspects of the transfusion service in a more general way—for example, by providing informative leaflets. Some services give donors regular bulletins and in some places donors form their own associations to maintain their interest in transfusion and stimulate that of others.

Other ways of stimulating donor recruitment include:

1. The collection of blood from athletes the day before they take part in a sports meeting or match, to demonstrate that blood donation in no way affects physical effort.

2. The use of specially designed stamps and postal cancellation marks.
3. The distribution of enrolment cards to hospital visitors whose relatives or friends have received transfusions.
4. The presentation of silver or gold donors' badges (see above) at a meeting of an organization to which the donor belongs or by a local personality at a special ceremony.

Samples of propaganda brochures, posters, badges, etc., for the recruitment of unpaid donors may be obtained from the League of Red Cross Societies, 1211 Petit-Saconnex, Geneva, Switzerland.

CHAPTER 2

Possible Complications of Blood Donation and Diseases Transmissible by Transfusion

Neither blood donation nor blood transfusion is completely free from risk. The risks of donation are generally very slight, but none the less real, when the donors are fit and well; they are somewhat greater if volunteers unfit to give blood are accepted. Some of the risks to which the recipient is exposed are inherent in every transfusion, but others may be due to uncritical acceptance of donors. It is necessary to consider some of the possible complications before proceeding to the medical examination of donors.

Protection of the donor's health

When considering how to protect the donor's health, it is convenient to consider first the possible risks each time blood is given.

Risks associated with the act of donation

1. Local damage

If the technique of venepuncture is imperfect, a haematoma may result. This rarely leads to thrombosis, but may cause temporary discomfort and some limitation in the use of the arm and may render the veins less suitable for further donations or injections.

If the skin is thoroughly cleansed and covered with a dressing after donation, there will be little chance of infection at the site of venepuncture.

Occasionally the taking needle may in error be inserted into an aberrant artery. The resulting donation is very rapid with a pulsating flow of bright red blood. Provided the incident is recognized, prompt elevation of the limb, application of a dressing and a suitable pressure bandage to the puncture site, followed by a period of observation, are generally the only treatment required.

Local dermatitis due to hypersensitivity to a skin disinfectant, a local anaesthetic, or plaster is sometimes observed.

2. Systemic reactions

Circulatory. The most frequent reaction to blood donation is fainting. The symptoms in their usual order of appearance are: abdominal discomfort, increasing pallor, sweating, yawning, giddiness, blackness before the eyes, hypotonia of the muscles, and finally loss of consciousness. Contrary to what might be expected, although the blood pressure is low the pulse rate is retarded, which is typical of a vasovagal attack rather than a condition of shock due to loss of circulating blood volume. The treatment consists of discontinuing the donation, reassuring the donor, loosening any tight clothing, and maintaining the donor in a supine position, possibly with the legs raised. Recovery is usually rapid. This reaction appears to be more common among new donors and particularly among more intelligent and imaginative persons. Emotions play a considerable role in causing fainting, and once one donor is seen to faint an "epidemic" of fainting due to mass suggestion may occur.

In occasional instances the fainting syndrome is due to inadequate reaction of the circulation to the decrease in blood volume. Temporary vasodilatation in the muscles and splanchnic vessels results in momentary cerebral hypoxia.

Fainting occurs in 1%-6% of donors; the higher incidence, however, includes mild cases with only early signs and symptoms. If more than 400-420 ml of blood are taken, the frequency of fainting will increase, especially in young people and asthenic donors.

Donors with circulatory disorders are especially subject to cardiovascular disturbances due to the rapid haemodynamic alterations. Coronary and cerebral thrombosis have occasionally been observed several hours after blood has been taken from persons suffering from arteriosclerosis and high blood pressure. Hypertensives with average systolic blood pressure of over 200 mm Hg or diastolic pressure of over 110 mm Hg must be excluded from donation. Many experienced medical officers exclude donation at a lower systolic level than this. It is also advisable to reject hypotensives with an average systolic blood pressure below 100 mm Hg or a diastolic pressure below 60 mm Hg.

Air embolism. Air embolism can be avoided by carefully preparing the equipment and by following the correct technique of blood collection (see Chapter 8, p. 66).

Evidence of air embolism may vary from cessation of blood flow and the sight of air bubbles passing up the taking set into the donor's vein to anxiety in the donor, accompanied by cough and chest pain, with cyanosis, cardiac irregularity, and abnormal heart sounds in extreme cases.

If an air embolus is suspected, pressure in the sphygmomanometer cuff must be immediately increased and the taking needle rapidly removed. These actions must be undertaken promptly without worrying about leakage

from the puncture site. The donor should be turned on his left side to keep any air bubbles in the right atrium, and his head should be lowered over the side of the couch.

Tetany. Hyperventilation tetany is a very rare complication which may be observed as part of the fainting syndrome in anxious donors.

Hepatitis. To avoid the possible transmission of serum hepatitis from donor to donor all needles (i.e., intravenous, hypodermic, and skin lancets) must be adequately sterilized and fresh ones used for each donor.

The possibility of transmitting serum hepatitis in the course of blood transfusion is discussed on p. 24.

Reactivation of previous illnesses. There is no reason to exclude potential donors who have recovered from a minor tuberculous infection without complications more than five years previously. However, volunteers who have suffered from advanced tuberculosis, e.g., of the lungs, bones and joints, or urogenital system, and in whom the disease has left permanent lesions, should be rejected. Those suffering from chronic diseases, such as diabetes, kidney disease, epilepsy, asthma, or psychosis, or known to have had cancer should be rejected. There is always danger of exacerbation which can raise the legal question of responsibility. It must be clear to the general public that only persons in good health are accepted as donors.

Risks associated with repeated donation

With repeated donation, disturbances in the haemopoietic system may occur.

The human body varies in its reaction to the rapid removal of nearly half a litre of whole blood. In some donors it is difficult to detect any change in haemoglobin level, red cell count, or plasma protein fractionation. In healthy donors the plasma volume is restored in a few hours and the plasma protein concentration, if lowered immediately after giving blood, returns to normal in 1-2 days. Replacement of the lost red cells is a slower process. If 400-420 ml of blood are taken the haemoglobin level will fall by an average of 1 g/100 ml, while approximately 200 mg of iron will be lost. If the donor has no iron deficiency, the erythrocytes and the haemoglobin level will generally return to normal within 3-4 weeks.

With frequent donations at short intervals, there is a serious danger of sideropenia, particularly in women, who lose about 600 mg of iron yearly through menstruation. During pregnancy approximately 400 mg of additional iron is supplied by the mother to the fetus; during breast-feeding 1-1.5 mg of iron is lost daily. Sideropenia may be suspected from symptoms of fatigue, weakness, headaches, and palpitations. The longer it lasts the more likely it is that a secondary iron deficiency anaemia will develop, with

the usual signs of deterioration of the nails, fissures at the corners of the mouth, and dysphagia.

To prevent iron deficiency in donors, an interval of at least 3 months between donations must be maintained. Women should never give more than three nor men more than four donations of 400-420 ml per year, and ideally the aim should be to recruit enough donors to meet the need for blood with only two donations a year from each donor. Donors with a haemoglobin level of 12.4 g/100 ml or less should be rejected and referred to their doctor for advice and treatment. In some countries it is customary to reject male donors with a haemoglobin level of 13.1 g/100 ml, or less, as this degree of anaemia in males is frequently of greater clinical significance than one of 12.4 g/100 ml in women.

If, in view of local conditions, it is considered that donors would benefit from supplementary iron given orally, then a sufficient quantity of an easily absorbed preparation of iron, for example, 100 mg of ferrous sulfate or an equivalent preparation, should be taken 3 times a day for 7 days.

On any container used for dispensing iron tablets, it must be clearly marked that the contents are poisonous to children.

Protection of the recipient's health

Risks to the recipient of a transfusion may arise from :

- (a) transmission of disease or allergy from donor to recipient ;
- (b) accidents through careless preparation of blood and blood derivatives ;
- (c) immunological incompatibility between donor and recipient.

Transmission of disease by transfusion

1. Viral hepatitis

The transfusion of blood, plasma, and certain plasma fractions may transmit viral hepatitis. Two forms of viral hepatitis transmitted by transfusion are recognized : infectious hepatitis, and serum hepatitis. Both have the same clinical picture, and human beings are the only known source of infection. Patients with clinical jaundice are not the main source of the disease ; far more significant sources are the mild anicteric case, the convalescent carrier, those incubating the disease, and the healthy contact carrier, all of whom at one time or another may be viraemic.

Infectious hepatitis is an " open " infection. Towards the end of the incubation period and during illness, the virus is present in the faeces. In the majority of cases infection is peroral, transmitted either by direct close contact or through the consumption of contaminated food (water, milk, etc.). Parenteral infection by transfusion or the use of contaminated

instruments for injection or scarification is possible during the viraemic stage, i.e., towards the end of the incubation period and in the 3-4 weeks following the appearance of the first signs. The incubation period is short: 15-30, rarely up to 50, days. Infectious hepatitis chiefly attacks younger people. Incidence reaches a peak in late summer and early autumn, and the infection is endemic in most countries. The case fatality is about 0.2%.

Serum hepatitis on the other hand is almost always a "closed" infection. As far as is known the causative agent is not excreted. It is, however, present in the blood during the incubation period, several weeks before the appearance of jaundice, and it may persist for a long time; cases have been recorded in which the blood was still icterogenic 5½ years after recovery from the disease. The causative agent is apparently almost always transmitted by procedures in which the skin or mucous membranes are pierced (transfusion of contaminated blood or blood products; the use of contaminated syringes, scarifiers, vaccination lancets, tattooing needles, dental instruments, etc.) or by contamination of a wound with infected material.

The disease is characterized by an extraordinarily long incubation period (50-160 days) and there is no seasonal variation in incidence. Most cases occur in adults. The case-fatality rate is higher than that for infectious hepatitis.

Sporadic cases or outbreaks of the disease have been reported among the staff of transfusion laboratories and haemodialysis units. Staff handling blood, blood derivatives, transfusion equipment, or any other equipment soiled with blood or blood derivatives should take care to minimize contact with blood.

Recently an antigen, known as Australia (hepatitis-associated) antigen has been shown to be closely associated with serum hepatitis. The presence of the antigen and its antibody can be detected in human beings by appropriate laboratory tests (Informal consultation on viral hepatitis, 1970). This is of great potential significance to transfusion services, because it seems probable that the detection and exclusion of donors shown to carry the antigen or its antibody will reduce the risk of transmitting serum hepatitis by the transfusion of blood or blood products.

2. Syphilis

The transfusion of blood infected with *Treponema pallidum* is usually followed within 9-10 weeks by the appearance of a typical secondary eruption. The transmission of syphilis has become less frequent with the increasing use of stored blood. It has been shown experimentally that refrigeration for 72-96 hours at a temperature of 2°-6°C will kill the *T. pallidum* in whole blood and liquid plasma. The organism is also killed by freezing and freeze-drying. No guarantee of safety is given by a negative

syphilis test of the donor's blood since serum reactions are negative during the 3-4 weeks' incubation period following infection, and in about one-third of patients with a clinical primary infection.

Experience has shown it is usually sufficient to test donations by a reliable flocculation reaction with a cardiolipin antigen; tests with both a flocculation and a complement-fixation reaction may be preferred. Unless the result is negative, the tests should be repeated and additional tests, such as the treponemal immobilization test, used.

3. Yaws (*framboesia*)

As for syphilis.

4. Post-transfusion brucellosis, salmonellosis, and leptospirosis

Potential donors who have a recent history of brucellosis or salmonellosis should be excluded. Donors with a recent history of leptospirosis should be excluded for one year.

5. Tropical diseases

The risk of transmitting malaria is only slightly reduced by the use of stored blood since all three malaria parasites (*Plasmodium vivax*, *P. malariae*, and *P. falciparum*) survive refrigeration for several days and even weeks with little change in their powers of infection. Donors with a history of malaria and those returning from malarious areas should therefore be excluded from donation for whole blood. Their plasma, if freeze-dried, may be used. In endemic areas the use of malarious blood may be unavoidable, in which case the recipients should be given 200 mg of chloroquine daily for 4 days. In areas where trypanosomic diseases (African sleeping sickness, Chagas' disease), leishmaniasis (kala-azar, oriental sore), and relapsing fever are endemic, a negative history is of little significance because of the high incidence of the disease. Potential donors should therefore undergo an erythrocyte sedimentation test and blood film examination. These tests are discussed in the next chapter.

Helminthiasis, amoebic dysentery, yellow fever, dengue, Rift Valley fever, sandfly fever, and arthropod-borne encephalitides are not absolute contraindications to blood donation. Volunteers who have suffered from any of these conditions may donate once the disease has been cured.

6. Post-vaccinal states

Primary smallpox vaccination causes, after 6-7 days, a generally febrile reaction of several days' duration, during which a viraemia is present. After revaccination, the reaction is quicker and less severe. To prevent transmission of virus by blood transfusion, potential donors should not

be bled if they have been vaccinated against smallpox in the previous 3 weeks.

The same rule should apply for 3 weeks after yellow fever vaccination.

Potential donors vaccinated against rabies should be suspended from donation for at least 3 weeks.

Immunization against poliomyelitis may be carried out by the oral administration of an attenuated live vaccine. This vaccine causes little or no generalized reaction, does not increase in virulence as a result of passage through the body, and should not in any way endanger the health of a patient to whom it is accidentally transmitted by transfusion. While it is considered advisable that donors should not give blood for 2 weeks after receiving oral poliomyelitis vaccine, this is not obligatory.

7. Allergies

Transfusion of whole blood or plasma from a donor suffering from an acute allergic attack may temporarily sensitize the recipient by introducing allergens or reagins. Allergic donors should therefore be excluded from donation during attacks. Potential donors who have been immunized with animal sera within the preceding 3 weeks should be excluded, in order to prevent primary sensitization to animal protein or allergic complications in recipients already sensitive to animal protein.

Accidents due to errors in collection or storage of blood

Risks to recipients arising from errors during the collection or storage of blood are generally attributable to the use of incorrectly prepared anticoagulant, bacterial contamination, storage at the wrong temperature, or any cause which increases the number of non-viable or, in extreme cases, haemolysed red cells (e.g., heating, freezing, or excessive age of red cells).

Methods of routine organization designed to eliminate these risks are discussed in later chapters.

Immunological incompatibilities

Frank incompatibility between antibodies already present in recipients and donor red cell antigens can be avoided by the use of adequate cross-matching techniques, as described in Chapter 13.

In rare instances, such tests may be inadequate since a patient may have no detectable antibody, but nevertheless already be sensitized to an antigen in the donor's cells. In these circumstances the donated cells are rapidly eliminated. It is still not possible to examine routinely all samples for leucocyte antibodies. Those prescribing blood transfusions

should always be aware of these admittedly rare, but nevertheless real, dangers.

Any reaction occurring in the patient within 48 hours of transfusion, and possibly due to the transfusion, should be reported immediately by the clinician in charge of the patient to the transfusion laboratory so that appropriate investigation and treatment can be undertaken without delay.

CHAPTER 3

Selection and Medical Examination of Donors

The problems that arise in the selection and medical examination of donors vary considerably from one country to another. The use of unpaid volunteer donors is an important safeguard in itself, as it ensures that there is less temptation for the donor to attend if he does not feel fit. Fortunately, in most countries the development of the general medical services is at least parallel to, if not in advance of, the development of the transfusion services. Thus the busiest donor sessions will usually be held where the selection and medical examination of donors have become less onerous, because of the general high standard of health education and public health supervision. In countries where the health services are less highly developed, and in particular where there are endemic tropical diseases that may be transmitted by blood transfusion, a more searching medical examination of potential donors is required. In some centres this may be extended to include a chest X-ray and a complete urinalysis. It is possible that in some countries the opportunity of such a comprehensive medical examination free of charge might even assist donor recruitment. Examinations of this type should hardly be necessary where there is a free national health service.

Although it is possible to formulate general rules for the selection and examination of donors, these will need to be modified or extended in the light of local circumstances and experience.

Selection

1. The lower and upper age limits for blood donation are generally 18 and 65 years. In some countries donors under 21 years of age must have the consent of a parent or guardian.
2. The normal donation of blood (usually 420 ml) should not be taken more than 3 times annually from women and 4 times annually from men. There should be a minimum interval of 3 months between donations. The aim should be to recruit enough donors to ensure that none of them is asked to give blood more than twice a year.
3. Donors with hazardous occupations, for example aircrew, train, bus, and crane drivers, steeplejacks, etc., should give blood only after finishing work for the day.

Medical examination

Before each donation the donor should be examined to determine his suitability. The findings of this examination should be strictly confidential. It should include: medical history; physical examination; and laboratory tests.

Medical history

The medical history may be taken by a doctor, a nurse, or a specially trained clerk who interviews the donors, or by means of a questionnaire completed by the donor. The points that should be covered include the health of the donor in recent months or since the last donation, and previous medical treatment or hospitalization. There should also be a brief interrogation dealing with the central nervous system, heart, blood circulation, lungs, and the gastro-intestinal and urogenital systems, as well as questions on allergies, diabetes, epilepsy, and hepatitis.

Pregnant women should not be bled. Nursing mothers should not be bled for at least 6 months after childbirth or for as long as they are breast-feeding. An exception may be made where blood is taken, under strict medical supervision, to obtain blood-grouping sera. Menstruation, apart from acute menorrhagia, is not a contraindication to blood donation.

Potential donors should not:

- (a) be bled within 3 days following tooth extraction;
- (b) have had any serious febrile illness or major surgical operation during the preceding year or have received a transfusion in the previous 6 months;
- (c) have had any minor febrile illness during the previous 3 weeks;
- (d) be bled during any acute attack due to allergy.

Persons with chronic illness, cardiac insufficiency, renal damage, nervous complaints, psychosis, diabetes, etc., should not be accepted as donors.

Blood taken from patients with polycythaemia vera or hypertension should not be used, and in general it is not desirable to undertake therapeutic venesections at public donor sessions. If blood is taken from patients with haemochromatosis, it should be used only for plasma or fractionation.

The previous chapter gives guidance on the management of potential donors who have recently been vaccinated or who have a history of any of the following infectious diseases: amoebic dysentery, arthropod-borne encephalitis, brucellosis, Chagas' disease, dengue, helminthiasis, hepatitis, leishmaniasis, leptospirosis, malaria, Rift Valley fever, salmonellosis, sandfly fever, syphilis, tuberculosis, undulant fever, yaws, yellow fever.

If the medical history raises any doubt as to the wisdom of blood donation, the doctor should ask further questions and, if necessary, arrange for laboratory investigations.

Physical examination

Depending on local conditions the physical examination will vary from a comprehensive clinical examination, including special tests, to the very simplest assessment of weight, pulse rate, and blood pressure. During this examination the medical officer should be able to pick out those prospective donors who may be, for example, undernourished, crippled, mentally unstable, alcoholics, or drug addicts.

It is customary to take less blood from donors weighing under 60 kg; 300–400 ml can be taken according to weight. Smaller amounts should not be collected into the usual volume of anticoagulant.

Potential donors should be rejected if:

- (a) they are found to be hypertensive;
- (b) they are found to be hypotensive with blood pressures below 100/60 mm Hg;
- (c) they show clinical signs of disorders of the circulatory system (decompensation, angina, irregular pulse, etc. — those with pulse rates over 120, or below 50, beats per minute should also be excluded);
- (d) they are found to have a raised body temperature.

Laboratory tests

Haemoglobin. No donor with a haemoglobin level of less than 12.4 g/100 ml (85%) should be accepted, and an increasing number of transfusion services are using a minimum acceptable haemoglobin concentration of 13.1 g/100 ml (90%) for male donors. The Phillips-Van Slyke copper sulfate technique (Phillips et al., 1950; Van Slyke et al., 1950a, 1950b) has proved a reliable method for estimating haemoglobin at donor sessions and is now in general use. The equipment needed is portable and thus suitable for mobile sessions. From those failing this test a small venous sample should be collected into anticoagulant for examination in the laboratory by alternative methods of haemoglobinometry and for stained film examination, if indicated.

Syphilis. A screening test for syphilis should always be made. One sensitive flocculation reaction is usually sufficient, e.g., the VDRL test, the Kline test, or other cardiolipin reaction. Unless the result is negative a full investigation should be made (see Chapter 2, p. 25).

Tropical diseases. In the case of donors resident in tropical areas, or recently returned from such areas, blood film examination for parasites

and a Westergren sedimentation test should be carried out. Persons with blood parasites or a high sedimentation rate (over 20 mm in the first hour for men, and over 30 mm in the first hour for women) should be excluded.

Other examinations. On occasion the medical history or examination may indicate that additional examinations should be made before accepting a person as a donor, e.g., urinalysis, biochemical examination of the blood, X-ray.

In all cases it is the responsibility of the medical officer in charge of the donor session to decide whether or not an individual is fit to give blood. Those who are rejected should be tactfully informed of the reason and if necessary referred to their own doctor. In this way the blood transfusion service can play a helpful part in the supervision of public health.
