The transition from the second to the final stage of treatment must again be gradual, so that four weeks after the beginning of all treatment the patient is following a regime somewhat as follows:

8 a.m.—Belladonna.

8.30–9.30. a.m.—One egg, and two very thin crisp rashers of bacon. Three pieces of thin crisp toast or three breakfast biscuits, with butter, honey, or red currant jelly. Two cups of milky coffee or tea.

10 a.m.—Alkaline powder.

11 a.m.—Milk or milky coffee.

12 noon.—Alkaline powder.

1 p.m.—4 oz. of boiled or steamed fish. 3 oz. of well-mashed milky potato. Milk pudding, junket, baked custard, or stewed apple with cream.

2.30 p.m.—Alkaline powder.

4.30 p.m.—Two cups of tea with milk and sugar. One slice of sponge cake.

5.30 p.m.—Alkaline powder.

7–7.30 p.m.—Omelette or minced chicken. Mashed turnips, purée of peas, vegetable marrow, or well-mashed milky potato. Sweets at lunch (1 p.m.).

8.30 p.m.—Alkaline powder.

10 p.m.—Hot milk or ovaltine.

10.30 p.m.—Alkaline powder.

The above regime may be gradually varied by allowing soft foods such as lightly cooked liver or boiled chicken, a grilled cutlet, etc., to be taken occasionally as a substitute for fish. Indeed, a little ingenuity will permit the selection of an entirely palatable and adequate diet provided that the rules as to the consistency and mechanical qualities of the food are always remembered. A close study of the patient's personal habits and occupation must be made in order that the hours of meals may be adjusted to suit him. It is usually necessary to see such patients after they have been back at work for some weeks or months in order to be sure that they are being reasonable as regards the hours of meals and the quality of their food.

Alcohol, Tobacco, and Forbidden Foods

Much has been written about the deleterious effect of alcohol and tobacco in cases of peptic ulceration. There is no evidence that alcohol should be prohibited provided that moderation is strictly observed. My custom is to prohibit the taking of either very large drinks or very strong drinks; the bulk of the former is as risky as the strength of the latter. Patients should be informed that one of the risks of alcohol is that, taken before meals, it tends to induce an exaggerated appetite and to cause temptation to exceed reason in the amount of food subsequently eaten. Tobacco is undoubtedly deleterious to anyone with a tendency to peptic ulcer, but so many cases are met with in patients who have never smoked in their lives that it is absurd to say that it is more than an accessory factor. I usually ask patients to give up smoking altogether, and warn them that if they cannot do this they must remember that anything beyond strict moderation is dangerous.

A list of forbidden foods has the disadvantage of making some people think that anything that is not on the list is all right. The patient should therefore be warned that such a list cannot be inclusive, but merely contains the most dangerous foods. An appropriate list is as follows:

1. All hard raw fruits and vegetables such as nuts, apples, pineapples, pears, lettuce, cucumber, celery, and tomatoes.

2. All really tough or hard cooked fruits and vegetables such as cabbage, carrots, unmashed turnips, new potatoes, stewed pears, pickles.

3. Tough meat, poultry, game, or fish.

4. The less digestible starchy foods such as pastry, fruit cake, new bread, suet puddings, etc.

5. Jams, etc., containing pips and skins. Currants, raisins, and figs.

6. Strong condiments such as vinegar, mustard, curry powder, and chutney.

7. Cheese, with the exception of the lightest forms of cream cheese.

BLOOD TRANSFUSION IN PRIVATE PRACTICE

BY

G. H. MACNAB, F.R.C.S.

SURGICAL REGISTRAR, WESTMINSTER HOSPITAL; LATE RESIDENT
MEDICAL SUPERINTENDENT, HOSPITAL FOR SICK CHILDREN,
GREAT ORMOND STREET

Each hospital in this country has its own tried and trusted method for performing blood transfusion, and team work shared by the operator, the pathologist, and a specially trained nursing staff is the keynote to success. In private practice success lies in simplicity, so I have written this article to bring to notice a method which fulfils that purpose.

Technique of Blood Grouping

The materials required are: two haemocytometer pipettes; stock sera 2 and 3; a pencil microscope; 1-oz. bottle of 3.8 per cent. citrate solution; 1-oz. bottle of 0.9 per cent. saline solution; glass slides; platinum loop; small test tube; and a Hagedorn needle.

On arrival at the patient's home three glass slides are warmed under hot water and cleaned. One drop of serum 2 is added to the left half of the slides A and B, and one drop of serum 3 to each right half. Eight drops of 0.9 per cent. saline and one drop of 3.8 per cent. citrate solution are placed in the small test tube. A donor is selected from the assembled relatives, the ear

FIG. 1.

pricked, and blood drawn up in the haemocytometer pipette to the mark 1, and diluted to 1 in 100 by drawing up 0.9 per cent. saline to fill the bulb. At the same time one drop of blood is added to the solution in the test tube. The patient's ear is then pricked and the blood diluted to 1 in 100 in the other pipette and one drop of pure blood placed on slide C. One drop of the patient's blood solution is added to serum 2 and 3 on slide A. One drop of the donor's blood solution is added to serum 2 and 3 on slide B. One drop of the test tube solution is added to the drop of blood on slide C. (Fig. 1.) The pencil microscope (Fig. 2) is now applied. It is a

FIG. 2.

light instrument, which can be carried in the vest pocket, and is capable of 120 magnifications. Blood cells are easily seen by resting the microscope on the glass slide and applying reflected light through a white cardboard box 3 by 3 by 2 inches, with the aid of a pocket torch. Slide A is examined for agglutination, then slide B, and finally slide C. The results are as follows:

Serum 2 agglutinated and serum 3 not agglutinated = Group 3.
Serum 2 not agglutinated and serum 3 agglutinated = Group 2.
Serum 2 not agglutinated and serum 3 not agglutinated = Group 4.
Serum 2 agglutinated and serum 3 agglutinated = Group 1.

Slides A and B show the group of the patient and the donor, and whether they are universal recipients or universal donors. Slide C proves that direct matching, as will take place in the transfusion, is correct if no agglutination is present. Agglutination is recognized macroscopically by small red specks appearing in the solution, giving the appearance of fine sand. Under the pencil microscope cells are seen running together, disintegrating, and forming adherent, irregular clumps. Agglutination in slide C requires the use of the pencil microscope, as the donor's cells are outnumbered 1 to 10, and only small areas of clumping occur, the remainder of the field being occupied by the recipient's cells floating in citrated serum.

Theory.—Red blood corpuscles contain one or both of two agglutinogenic substances, A and B, and human serum similarly contains one or both of two agglutinating substances, a and b: A and a cannot exist in the same individual, as the result would be agglutination. Four combinations are possible:

Group 1: No a or b.
Group 2: A and b.

Group 3: a and B.
Group 4: No A or B.

It is obvious from these facts that Group 1 is a universal recipient and Group 4 a universal donor. Unfortunately C and c have been discovered, and the Moss grouping has to be supported by direct matching to exclude C and c.

Warning.—The agglutinins of the donor's serum are ignored, as dilution to about 1 in 10 occurs on transfusion, but occasionally Group 4 has a high concentration of a and b. It is for this reason that I dilute the donor's blood in 0.9 per cent. saline and 3.8 per cent. citrate solution, so that the conditions for direct matching are the same as are present during transfusion. This point is best illustrated by carrying out direct matching between two known Group 4 and Group 2 persons. Make Group 4 act as the recipient and Group 2 as the donor, and agglutination will take place; but if the position is reversed and the same Group 2 person is made the recipient no agglutination will occur.

Incorrect Grouping.—This may give rise to a fatal result during or after transfusion. Haemolysis occurs, and the first signs are pain in the lumbar region, followed by flushing of the skin, then paling, perspiration, dyspnoea, cyanosis, failing pulse, and, finally, dilatation of the pupils and death. The patient may survive the initial shock, but in a few hours haematuria will appear, followed by albumin and casts in the urine. Several cases develop fatal anuria due to (1) haemoglobin lying free in the plasma acting as a renal toxin, or (2) blood pigment blocking the renal tubules and destroying their walls. This error is avoided by using sterile stock sera of high titre and by discarding donors who, apart from agglutination of their red cells, show haemolysis or rouleaux formation which is not easily broken up either with a platinum loop or by the addition of lecithin.

Cold Agglutination.—Always warm the glass slides before grouping, as agglutinins may act at low temperatures which at body heat have no effect. For the same reason transfuse blood at body temperature.

Blood Transfusion Apparatus

The apparatus included: 10 c.cm. three-way syringe; graduated 750 c.cm. pyrex glass flask with rubber cork and two glass connexions; hypodermic syringe and needles; donor's and recipient's needles; glass ampoule containing 100 c.cm. 3.8 per cent. citrate solution; instruments to expose a vein—scalpel, fine scissors, mosquito artery forceps, aneurysm needle, catgut, silkworm-gut, cutting needle, and ampoule of 2 per cent. novocain; rubber tubing, size 10 and 6 and glass connexions; towels, gauze swabs, and bandages; small rubber-bulb suction

pump. All these articles, except the suction pump, are kept sterile and ready for use in a drum 9 inches in diameter and 9 inches deep.

Removal of Blood from Donor

The donor is placed in the horizontal position and the median basilic vein selected. A small rubber band is placed around the arm, well above the elbow, and the correct amount of tension is obtained when the forearm shows blue and red mottling and the superficial veins become prominent. Rapid flexion and extension at the elbow-joint will increase venous congestion, as also will the cleaning of the surface with spirit. Beware of the large prominent vein that moves freely under the skin. This type of vein is often half punctured as it runs away from the approaching needle, and a haematoma forms, rendering further procedure at that point useless.

The vein having been selected, one or two minims of 2 per cent. novocain are introduced intracutaneously. A sharp needle of wide bore is now produced, the purpose of which is to slip through the skin and enter the vein. At this stage a point of difficulty arises. A needle of wide bore which increases in calibre from its point of entry permits of a free flow of blood with diminished friction, but the bulk of the needle prevents easy entrance through the skin to the vein. I have designed a needle¹ (Fig. 3) to overcome this difficulty. It is made of stainless

FIG. 3.

steel, and retains the principle of French's needle, in which a highly polished wide bore of increasing diameter tends to prevent coagulation of blood. From the bevel of the needle a cutting edge arises formed by grooving the needle on its under surface. The upper surface of the needle leads from a sharp point to a cutting edge formed by the meeting of two flat surfaces at an acute angle. The shoulder of the needle is bevelled to meet the cutting hollow-ground edge on the under surface, thus removing a sharp angle which would obstruct the passage of the needle through the skin. A portion of glass tubing one inch long is permanently fitted into the mount of the needle, and with its diameter increasing it leads to a bulbous end to which a portion of rubber tubing is attached.

The rubber tubing, size 10, is 18 inches in length, and leads to the pyrex flask resting on a table at a level lower than the donor's arm. The neck of the flask contains a rubber cork with two right-angle glass connexions passing through it. The donor's needle is attached to

FIG. 4.

one flask connexion and the suction pump to the other: 10 c.cm. of citrate solution (3.8 per cent.) is added to the flask for every 100 c.cm. of blood to be withdrawn. Citrate solution is run through all the connexions. The needle is now entered (Fig. 4) with the bevel next to the skin; this ensures that the whole lumen of the needle enters the vein at the same moment, and prevents puncture of the posterior wall. It is also useful if the vein collapses,

¹ The needle is made by Donald Rose, 36, George Street, London, W.1.

as the walls can be separated by lifting the needle up from the skin. Just before entering the vein, pause and pump the rubber bulb, thus creating a vacuum in the flask; the negative pressure produced sucks the cork tightly into position. The negative pressure in the bottle increases the rate of flow and prevents clotting, and the sight of blood in the glass portion of the needle is the only proof that the vein has been entered, and permits of concentration on the needle and not on the flask. Many a time have I seen a vein well and truly entered, and then the operator lose confidence and position as he twists himself to gaze into the depths of the flask and wait for the blood to wend its way round the coils of tubing. You must have a needle that enters a vein with ease and gives immediate indication of its entry. Coagulation in the flask is prevented by keeping it in motion to ensure uniform citration. The blood having been obtained, the rubber band is released with one hand, a pad of wool put over the site of the needle puncture, and the needle withdrawn. With my needle the diamond-shaped cut falls into a fine, straight line, and bleeding stops at once. A small collodion dressing can be applied, or merely a drop of iodine. The flask is placed in a small retort stand in a basin of warm water and carried to the side of the patient.

Infusion of Blood into the Patient

The 10 c.cm. three-way syringe² (Fig. 5) is now assembled. It consists of a metal handle carrying a metal cup to which are attached three outlet taps. The cup receives a carefully fitted cylindrical block of steel, which is in connexion with a 10 c.cm. syringe. The channel opening from the syringe through the block of steel can be made to come

FIG. 5.—Three-way syringe. A is attached by rubber tubing to flask containing blood. B is attached by rubber tubing to transfusion needle.

into line with any one of the openings in the cup by moving the syringe through the arc of a circle. The two parts of the apparatus are kept in contact with a metal clip, easily inserted. Rubber tubing with a lead weight is attached to one outlet and allowed to sink to the bottom of the flask. To another outlet is attached rubber tubing leading to a fine glass connexion and needle (Record, serum size 1). Citrate solution is drawn into the syringe through the third outlet, the tubes to flask and needle are filled, and all air is driven out. The needle is now inserted into the patient's median basilic vein, and blood immediately enters the capillary tube. The barrel of the syringe is withdrawn, and any air left in the tube enters the syringe and is evacuated through the third outlet. The residual citrate solution in the syringe is injected to prevent clotting at the needle point, and then the syringe is turned over to outlet 1 and blood drawn up from the flask, any air present being ejected through outlet 3. The apparatus is now free from air and the infusion of blood is carried out.

I have found that for patients less than 7 years old the vein has to be isolated and a cannula used. The

vein to isolate is the internal saphenous as it crosses the surface of the internal malleolus. The vein is deeply situated at this point, and lies next to the periosteum covering the bone. Novocain (2 per cent.) is injected, and then the skin is superficially incised with a scalpel. The scalpel is now laid aside and the remainder of the dissection carried out with blunt-pointed scissors. The middle of the incision is lifted up with fine-tooth forceps, and the tissues opened with scissors until the vein comes into view. With this method the vein will never be ruptured. The vein is now picked up with non-toothed forceps and cleared on all sides. Two strands of catgut are then passed under the vein on an aneurysm needle, and the distal one is tied with a single knot while the proximal one is formed in a loop. The portion of vein between strands of catgut is now held taut, and a pair of mosquito forceps are applied at an angle of 45 degrees to the anterior wall of the vein. A valvular flap is now cut with scissors close to the forceps, and the flap is raised, exposing the lumen of the vein. Escape of blood from the vein is controlled by increasing tension on the strands of catgut. A cannula takes the place of the recipient's needle, and blood transfusion is carried out as previously described.

The Cannula.—For infants I use a very fine cannula made of silver. The essential point is that the end of the cannula has rounded edges. If the edges are merely blunt they will catch in the endothelial lining of the vein and destroy the lumen. A large number of cases of so-called spasm of the vein are due to this fault, the proof being that if a probe twice the diameter of the cannula is inserted it will pass freely up the lumen. Beware of passing the cannula between the sheath of the vein and its wall; proper dissection will prevent this error. As soon as the cannula is inserted the proximal catgut strand is tightened on it with a single knot. After transfusion the cannula is withdrawn, the strands of catgut removed, the skin sutured, and a pressure pad applied. Leak from the vein is thus easily controlled.

The Syringe.—Its value is now apparent. It provides for a carefully regulated flow and for pressure required in the transfusion of dehydrated infants. It takes the place of all types of positive pressure apparatus, and the third outlet prevents air-locks holding up the flow of blood in the tubes.

Rate of Infusion.—I consider that 20 c.cm. of blood per minute in a full-grown adult is ideal; in an infant, 8 c.cm. per minute. If the patient is very ill, apart from the loss of blood, the rate should be slowed down. In infants a slow rate of infusion of the first 20 c.cm. prevents sudden dilatation of the right side of the heart.

Reactions.—During the transfusion the patient may complain of pain in the chest or difficulty in breathing, or in more serious cases show signs of collapse. The majority of these reactions are due to too quick a rate of transfusion. Impurities in the citrate solution have been blamed in the past, but if normal saline is infused rapidly the same reactions will be noted. Rigors are sometimes seen after a transfusion, due to the same cause. When infusing blood through the basilic vein slow down the rate, as the valved system in the internal saphenous vein is not present. Reactions due to wrong grouping have already been described.

Summary

A safe method is employed in which the patient's serum is not required. Time and the use of a centrifuge are saved. The stock sera are kept ever ready in a case and only require changing each six months, as deterioration is a slow process. There is no difficulty in obtaining blood from the patient, as only two drops are needed. Direct matching is carried out under conditions approximating to those of transfusion, acting as a check on the

² The direct flow three-way syringe is made by John Bell and Croyden, Wigmore Street, London, W.1.

Moss grouping and avoiding error due to the donor's agglutinins. The light pencil microscope relieves the burden of carrying around the standard microscope.

The apparatus is simple. A new needle has been designed in which a wide bore has been retained, and yet it can glide through the skin, due to its hollow-ground cutting edge and reduction in bulk. The pyrex flask is light and easily sterilized, and its broad base provides a large surface area of citrate for the entering blood to mix in. The rubber cork with glass connexions is sucked into position with the rubber suction bulb, a vacuum created, and a rapid flow ensured. The rubber bulb does not require to be sterilized; therefore long life is ensured. When the blood is withdrawn the flask is clamped in its stand in warm water and no fear of upset arises.

From the age of 7 years onwards there is no need to cut down on the vein. The three-way syringe permits of definite control of the rate of infusion, and in infants allows pressure to be applied to introduce the first few cubic centimetres of blood. The fine-thread glass connexion next to the recipient's needle fills with blood as soon as the vein is entered, and prevents the operator transfusing too quickly.

Average figures for the adult and for the infant are 20 c.cm. and 8 c.cm. per minute. Rapid transfusion accounts for the majority of the reactions, and in infants may lead to dilatation of the right side of the heart.

RISK OF ANAESTHETIC EXPLOSIONS

PRECAUTIONS IN OPERATING THEATRES

The Minister of Health has issued to the local authorities and to medical officers of health in England and Wales a memorandum dealing with the possibilities of explosions in operating theatres arising from the use of electrical apparatus in the presence of an inflammable anaesthetic.¹ The risk of a serious accident is a remote one, and has, in fact, been computed in America as not more than 1 in 100,000. Nevertheless, several explosions which have proved fatal to patients have been recorded, and the possibilities of such occurrences have increased within recent years. The Minister is insistent that his memorandum should not be construed as implying that either administering or receiving an anaesthetic is in any way a perilous adventure, but it is hoped that by drawing attention to certain dangers steps may be taken to minimize a risk which, though small, is inevitable in any surgical operation involving electrical apparatus and the administration of a general anaesthetic.

Three Factors Increasing the Risk

There are three factors which seem likely to increase the risk of anaesthetic explosions. First, the administration of ether and oxygen mixtures has become increasingly common in recent years. Secondly, there has been a considerable extension of the use of electrical apparatus with the development of such instruments as the sigmoidoscope, the cystoscope, the cautery, and surgical diathermy appliances. X-ray apparatus too is now more often used in the presence of an inflammable anaesthetic. Thirdly, the problem of static electricity as a determining cause in these explosions has been brought to the fore recently and is regarded as an increasing risk, since the introduction of artificial ventilating systems has produced conditions more favourable than formerly for its production.

The Choice of an Anaesthetic

The memorandum outlines in brief the results of a study which has been undertaken by the Ministry in consultation with the Factory Department of the Home Office. The matter has received, too, the attention of the Anaes-

thetics Committee of the Royal Society of Medicine and the Medical Research Council, with the co-operation of the National Physical Laboratory.² It is pointed out that a rich ether-oxygen mixture is more dangerous than a corresponding ether-air mixture, and a very small spark will suffice to cause ignition. The ordinary A.C.E. mixture may become explosive when mixed with air and used in proximity to any apparatus likely to involve the spark or hot wires. Nitrous oxide itself is not inflammable, but mixtures of ether and air or oxygen are rendered even more inflammable by the addition of N₂O. Ethyl chloride, the use of which has become more and more popular, particularly for the induction of anaesthesia in children, yields a vapour which produces an explosive mixture with air; and ethylene-oxygen forms a mixture which when ignited produces a very destructive explosion.

Where an explosive risk is anticipated the alternative methods of anaesthesia that are available include local analgesia, basal narcosis, nitrous oxide and oxygen, and, of course, chloroform. In certain cases, however, local analgesia may be impossible, and the use of these other non-explosive and non-inflammable anaesthetics may be contraindicated. For these cases, where ether in some form must be used, the risk of explosion may be considerably lessened by the employment of a rigidly closed circuit with carbon dioxide absorption. Under such conditions and with a tightly fitting mask, no anaesthetic should escape into the air.

In some types of anaesthetic apparatus an explosive mixture containing ether may be delivered although the valve or tap is set to admit chloroform or nitrous oxide only. This is due to evaporation, combined with the slight suction effect of the gas flow, and its occurrence is more likely where the ether bottle is surrounded by a hot-water jacket. The casual emptying of the ether container in such a case is no safeguard, but is possibly an added danger. The ether bottle should be completely detached and not replaced until all trace of ether has been removed, or, failing that, it should be fitted with an effective separate valve which completely closes the outlet from the bottle when ether vapour is not required. It has been established experimentally that ether-oxygen mixtures can ignite along an intratracheal tube. It follows, therefore, that if ignition does take place the flame may strike back through the anaesthetic tubing and reach the ether bottle.

Types of Electrical Apparatus

The essential feature of the surgical diathermy apparatus is the cutting arc or spark at the electrode which is definitely capable of igniting ether-air or ether-oxygen mixtures. A further risk of ignition arises, too, from the spark gaps within the cabinet and from the fact that the patient may be at an electrical potential, with a consequent risk of sparking to the operator or to other conducting bodies such as the table or anaesthetic apparatus. X-ray apparatus is perhaps only infrequently used in the presence of an inflammable anaesthetic, but where it is so used sparking may occur from a defect in insulation at switches, regulators, fan-cooling motors, or plug-and-socket connectors, the degree of danger depending on the ventilation and the proximity of the patient. Surgical lamps when used in diagnostic or in operative instruments must necessarily be of small dimensions, and this has led to a form of construction which, comparatively, is not robust, and which tends therefore to become unreliable with use. So too sparking may be caused by the accidental short-circuiting of exposed terminals or as a result of failure of insulation, or of intermittent contact, in the instrument and at the various switches. Such sparking is particularly dangerous in nose and throat operation when anaesthesia is being maintained by ether-oxygen. The design and construction of surgical lamps and of surgical electrical apparatus generally is the province of the manufacturers; but it should be remembered that the best designs may be rendered ineffective and consequently dangerous unless their maintenance is both careful and competent.

² See letters in *British Medical Journal*, December 7th (p. 1128), and December 14th, 1935 (p. 1174).

¹ Memo. 191 Med. H.M. Stationery Office. (1d.)