THE TRANSFUSION OF WHOLE BLOOD: A SUGGESTION FOR ITS MORE FREQUENT EMPLOYMENT IN WAR SURGERY.

BY

L. BRUCE ROBERTSON, B.A., M.B. TORONTO,
CAPTAIN C.A.M.C.,
JUNIOR ASSISTANT SURGEON, HOSPITAL FOR SICK CHILDREN,
TORONTO, CANADA.

THE investigations of Crile and Carrel and the more recent clinical and experimental work of Satterlee and Hooker,¹ and of Lindeman,² have shown the enormous value of the introduction of whole blood into the circulation, and have emphasized its limitations.

The broad indications for blood transfusion are based on the fact that transfused blood is the best substitute for blood lost in acute haemorrhages. In certain pathological haemorrhages it has definite haemostatic properties, and in some secondary anaemias it acts as a powerful stimulant to tide over the crisis in the disease. In haemorrhagic disease of the newly born brilliant results have been obtained, and recently the procedure has been applied in cases of haemophilia, pernicious anaemia, marasmus, and certain secondary anaemias due to purulent foci, with some very promising results.

In cases of primary haemorrhage in the present war we see the condition of the shock due, not only to the loss of blood, but to the injury causing the same. In secondary haemorrhage the patient's resistance is lowered owing to the absorption of toxins from an infective focus, and there is often, in addition, a lowering in the coagulability of the blood from the same cause.

To combat the alarming symptoms due to the abrupt loss of blood the introduction of normal saline solution is probably the treatment most frequently adopted, and in many cases, usually the less severe, this stimulates the patient, allows his natural resources to assert themselves, and recovery takes place. But the addition of salt solution to the circulation is at best only a temporary measure, and merely makes up for the loss of fluid, which is only one factor in the condition.

The Effect of Transfused Blood.

The introduction of whole fresh blood into the circulation at once not only helps to restore the depleted bulk of circulating fluid, but provides the patient with that particular body tissue to the depletion of which his immediate symptoms are due. Moreover, the newly introduced blood (1) acts as a more permanent addition to the body tissues, and (2) carries with it coagulation elements, fresh complement, and, to a varying extent, any antibodies with which the healthy donor's blood is provided. It is a stimulant to the starved haematopoietic organs, as may often be seen by the secondary increase in the blood count within a few days of the operation. The results are more apparent in cases of primary haemorrhage, in respect of which my observations have been limited to cases in civil practice. In secondary haemorrhage, where the factor of sepsis has to be combated, the additional blood often carries the patient over a critical period, and assists his forces to rally to withstand further surgical procedures necessitated by the infective process, or increases his resistance so that by his natural resources he overcomes the infection.

Where infection only is the factor to be combated, blood transfusion is simply an adjuvant to other means of treatment, unless a specific antibody can be introduced, as has been done recently by Zingher of New York, who injected blood from cured scarlet fever patients to others in the acute stages of the disease, with most promising results.

Possible Dangers of Blood Transfusion.

The occurrence of haemolysis during or after blood transfusion has occupied a good deal of attention. The milder degrees of incompatibility between the donor's blood and that of the recipient result usually in a slight chill and a rise of temperature (sometimes up to 102° F.). These symptoms are not uncommon even between familial bloods, and should occasion no alarm. The reaction is due, apparently, to the introduction of a foreign protein material or the liberation of some serotoxin. If any actual haemolysis occurs in these mild reactions, it must be very limited, as the great majority of patients show no haemo-

globinuria. A greater degree of incompatibility is indicated by a chill and rise of temperature with slight icterus and haemoglobinuria, and the most serious degree by these symptoms very much intensified, followed by collapse and death.

Selection of a Donor.

A robust and healthy donor can withstand the loss of from 600 to 1,000 c.cm. of blood without more than moderate temporary disturbance, and I have seen no ill effects in any donor following the transfusion, provided he is kept at rest for twenty-four hours afterwards. It is a simple matter at the end of a transfusion to give the donor a quantity of saline equal to the amount of blood withdrawn from his circulation. Donors can be sought for amongst the patients suffering from sprains, minor fractures, etc., who are in good physical condition but unfit for duty. The use of these men as donors in no way prolongs their period of convalescence. Inquiries, of course, should be made of the donor as regards previous illness, such as syphilis or tuberculosis, and, if feasible, a Wassermann reaction should be done.

Preliminary Haemolysis Tests.

Tests for haemolysis have been devised which meet the ordinary requirements for cases of haemorrhage. These should, if circumstances permit, be performed before transfusion is carried out. But this may be impossible or the condition of the patient may make it imperative that no time should be lost. The occurrence of a serious degree of haemolysis is uncommon, and the fatal outcome in Case III may perhaps be attributed to the use of a second donor, for the possibility of a haemolytic reaction between three bloods is much greater than between two. A rapid and simple method of testing donors for transfusion is that devised by Rous and Turner.³ In some of the anaemias and in cases of sepsis there are very probably products of absorption in the tissue cells of the recipient which by the introduction of fresh blood may be disturbed or set free in such a way as to produce a reaction manifested by chills and fever and possibly haemolysis.

Method of Transfusion.

Of the various methods of blood transfusion those involving the transference of the blood by an intermediate vehicle are to be preferred. The end-to-end anastomosis of artery and vein first advocated by Carrel, or the interposition between them of a paraffin-coated glass tube is a surgical procedure which necessitates considerable skill on the part of the operator and his assistants and consumes a valuable amount of time. They are not applicable when transfusion must be done at the bedside, and the amount of blood introduced cannot be estimated except in the most approximate fashion. Of the several indirect methods there are three in general use: (1) syringes and cannulae, (2) the Kimpton or similar cylinder with which sodium citrate⁴ or hard paraffin may be used as an anti-coagulant, (3) the Unger two-ways stopcock.⁵

It has been argued that the saving of time is a great factor in commending any particular method of blood transfusion. But this holds good only up to a certain point, and a too rapid introduction of blood into a patient's circulation has more than once led to cardiac dilatation and a fatal issue.

The Syringe-Cannula Method.

The method of blood transfusion which up to the beginning of the war I found most applicable in civil practice⁶ is the syringe-cannula method. It is with slight modifications the method popularized by Lindeman of New York, who has placed it on its present basis of efficiency.

The instruments used are a set of six 20 c.cm. Record syringes, two hollow needles which fit the syringes and are as far as possible of the same bore as the tip of the syringe, two 2-in. rubber tubes armed with metal tips which fit the needles, and a small set of dissecting instruments, the last named to be used when a superficial vein cannot be entered by direct puncture through the skin. If Record syringes are unprocurable, ground glass syringes of the same capacity will be found to answer almost as well, although they require more care in handling. The cannula used is of the pattern recommended by Lindeman, and contains a closely fitting inner hollow needle, which

projects beyond the end of the cannula and is bevelled in the usual way. Its introduction into the lumen of the vein is shown by the appearance of blood at the hub of the inner needle, and the latter can then be withdrawn, leaving the smooth tip of the cannula in the vein; in this way injury to the delicate intima and consequent clotting is avoided. Transfusion may often be carried out successfully with the ordinary sharp-pointed needle, but the increased possibility of clotting must be taken into consideration. Apart from the cosmetic effect and a slight saving in time and trouble, the method of introducing the needle or cannula into the vein is a matter of minor importance. It is a simple matter to cut down upon the vein under local anaesthesia and introduce a blunted needle or small olive-tipped glass cannula.

All instruments are sterilized by boiling. It should be noted, however, that with the Record syringes recently issued sterilization in methylated spirits is preferable, as the syringes are liable to crack when being boiled. Two 1-pint bowls of normal saline, one warm and one cold, and a small bowl containing about 1 oz. of sterilized liquid paraffin, are also required. The cold salt solution is used for washing out the syringes, the warm solution for injection through the cannulae to clear them of blood. The syringes, rubber tubing, and cannulae are lubricated by drawing through them the sterilized liquid paraffin.

Technique of Blood Transfusion.

The skin over the antecubital region of the recipient's left arm having been sterilized by painting with tincture of iodine, sufficient constriction is applied just below the shoulder to prevent venous return. The most accessible vein is selected, and the needle or cannula introduced and allowed to fill with blood. The constriction is now removed, and a 20 c.cm. syringe full of saline, with rubber tube and coupling attached, is connected with the cannula. Sufficient salt solution is now forced very slowly but continuously through the cannula to clear it of blood and prevent clotting. Constriction is now applied to the donor's arm until the veins are well distended and the skin pink but not cyanosed. An elbow vein is entered, and an empty syringe and rubber tube attached. If the cannula be introduced in a direction opposite to that of the blood stream it will be found that the syringe will fill more easily when the piston is withdrawn. The assistant now quickly withdraws 20 c.cm. of blood from the donor's vein, disengages the syringe from the rubber tubing, and passes it to the operator, who substitutes it for the saline syringe previously attached to the rubber tubing on the recipient's needle. The blood is injected into the recipient's vein quickly, and when the syringe is emptied it is immediately replaced by the saline syringe, and sufficient salt solution forced through slowly but continuously to clear the tubing and needle of blood.

In the case of the donor, a saline syringe is attached between the successive withdrawals of blood, and a small quantity of salt solution forced through slowly and continuously to keep tubing and needle clear of blood. After each blood filled syringe has been emptied the nurse flushes it out with cold sterile saline, and at intervals relubricates it with liquid paraffin. In this way syringes can be used an indefinite number of times, and the amount of blood which it is possible to transfuse is limited only by the giving capacity of the donor and the receiving capacity of the patient.

The recipient should be watched carefully for any signs of vasomotor disturbance. Not infrequently he will complain of some substernal or abdominal pain after the first few syringe-fuls of blood have been injected. These symptoms are probably caused by the introduction of a foreign protein. It is at this juncture that the operator should proceed slowly, and if necessary suspend operations for several minutes until the patient has quieted down. If the transfusion is to be suspended the cannulae should be kept patent by the slow but continuous injection of salt solution.

Every endeavour should be made to cause as little movement as possible of the end of the cannula in the vein, and it is on this account that the short piece of rubber tubing is used. If the cannula system is found to be blocked to the passage of saline the rubber tube and coupling should be removed and their patency ascertained. If clot is present here it can be forced out with saline, and the

operation resumed. If clot occurs in the needle it is usually to be found in the hub, and can be picked out with fine forceps. If necessary the cannula may be removed, cleared, and reintroduced. Strict attention to the saline introduction will prevent clotting. No doubt microscopic clots in the form of minute aggregations of red cells are introduced, but apparently these cause no trouble. On several occasions I have seen small bubbles of air introduced without any symptoms of cardiac disturbance.

The advantages of this method are: (1) Nothing beyond ordinary surgical technique is required. (2) The amount of blood transfused is known definitely. (3) The procedure is under control at all times. (4) Should symptoms occur in the patient which render it necessary, operations can be suspended for several minutes without risk of clotting. (5) Blood may be transfused slowly or rapidly. (6) The total quantity of blood is outside the body for a period not exceeding twenty seconds, and there is a minimum amount of foreign material with which it must come in contact.

Amount of Blood to be Transfused.

In primary haemorrhage, where the loss of blood is considerable and the shock severe, transfusion up to 800 to 1,000 c.cm. of blood will give the best results, though the amount given must depend on the requirements of the patient and, as noted above, the giving capacity of the donor. Some appreciable improvement may be obtained with smaller amounts, and in any case the procedure should be supplemented by the subcutaneous injection of normal salt solution.

Where small but repeated or persistent secondary haemorrhages occur a smaller amount (200 to 400 c.cm.) produces a haemostatic effect, but where severe secondary haemorrhage has taken place a larger amount should be given to get the best results.

Cases of Secondary Haemorrhage.

CASE I.—Sgt. G., wounded September 23rd, 1915, was admitted to a base hospital on October 6th, 1915, under the care of Major J. N. Gunn, C.A.M.C. There were multiple shrapnel wounds of chest and left arm, and the temperature was 102° to 104° F. Four days later thoracotomy was performed for empyema. By October 22nd there had been two severe secondary haemorrhages from the chest after which there was continuous oozing. By October 30th the condition had become much worse and the administration of salt solution subcutaneously caused no lasting improvement; the red blood cells reached 1,600,000. Blood transfusion (500 c.cm. by syringe-cannula method) was performed; after the first 80 c.cm. the patient complained of some abdominal discomfort and pain in the affected lung, the pupils became dilated and the face flushed. At this juncture the operation was suspended for ten minutes, and then, as the symptoms had subsided, further injections of blood were carried out at moderate speed. That evening the patient had his first good night's sleep without the aid of morphine. The following day the red blood cells numbered 2,500,000, the general condition was much improved, and there was no bleeding from the wounds. His condition continued to improve, and a month later he was evacuated to England. Further accounts from the patient showed an uneventful recovery.

CASE II.—Pte. G. was admitted to base hospital, October 13th, 1915, under the care of Major H. L. Jackes, C.A.M.C. He presented multiple septic shrapnel wounds of both legs, left arm, and head, and his general condition was very poor. The right leg had been amputated below the knee. The temperature was 100° F. and the pulse 132. A few days later various septic wounds were opened and shrapnel removed; the temperature was 100.4° to 103.8° F. On November 5th severe secondary haemorrhage occurred from the stump; the bleeding vessel was secured, and salt solution with pituitary extract administered interstitially. Six hours later the pulse was 140 and very soft. At 4 p.m. the same day 900 c.cm. of whole blood was transfused and immediate improvement was evident. During the transfusion the donor complained of no discomfort, and at his own request was allowed to smoke a pipe throughout the operation. Following this the patient showed great improvement, and on November 15th the temperature was 99° F. and the pulse 90. Three weeks after transfusion the wounds still showed a good deal of infection, and he began to have a septic temperature. At this time a blood culture showed streptococci; a week later he succumbed to the blood infection.

CASE III.—Pte. B., about December 7th, 1915, sustained a shrapnel wound of the left leg, necessitating amputation just below the knee at a clearing station. Several days later he arrived at the base in a toxic condition with severe infection of the stump. Secondary haemorrhage occurred four days later; the femoral artery was ligatured and amputation through the knee-joint performed. For the next week the temperature remained elevated, and infection of stump and thigh was present. On December 19th the red blood cells were 1,988,000 and haemoglobin 45 per cent.; the patient showed poor resistance to the infection and withstood the dressings badly. With the two-way stopcock apparatus of Unger 600 c.cm. of whole fresh

blood was transfused. Following this he showed improvement, and for the next week his progress was fair, but he seemed to have lost heart, and it was thought that a second transfusion would give him the desired stimulus. On December 28th (red blood cells 2,320,000, haemoglobin 60 per cent.) 450 c.cm. of whole blood was transfused with the two-way stopcock from a second donor. More than this quantity was not used, as towards the end of the procedure the patient complained of general discomfort, and within ten minutes after the operation the pulse became weak and rapid, respirations shallow and hurried, and he was only partly conscious. Stimulants were administered, and four hours later he was sitting up in bed smoking a cigarette. The following day intense jaundice was present, and he had passed a small quantity of very dark red urine. The pulse was weaker and there had been considerable bloody oozing from the stump. Twenty-four hours after this (the second) transfusion he became unconscious and died. At autopsy only a few petechiae were found beneath the serous coat of the small intestine, the liver was fatty, the kidneys and spleen dark red. No sign of pulmonary embolus or infarct could be found. Death was due, apparently, to acute haemolysis.

CASE IV.—Rfm. M., under the care of Major T. R. Elliott, R.A.M.C., who was kind enough to furnish me with progress notes, sustained multiple shrapnel wounds on December 14th, 1915. Three days later he was admitted to base hospital in very bad condition, with septic wounds of the left knee, right ankle, and left lung. On the twelfth day after the injury trismus appeared simultaneously with the expectoration of gangrenous pus from the lungs. Tetanus developed rapidly on the next day, causing rigid trismus and board-like abdomen, but no spasms nor difficulty of respiration. The condition of the patient was very pitiable, since he could not void from his mouth the fetid material that continued to come up from the lung abscess on the left side. Antitetanus serum was given until January 6th (a total of about 60,000 units). On the twenty-seventh day after the injury secondary haemorrhage occurred twice from the septic wound of the left knee. The vessel was ligatured. The blood lost was estimated as being rather less than a quart; the patient was much blanched. For the next week the general condition became worse, and there were signs of consolidation at the base of the left chest. No pus was found on exploration. On January 17th, before transfusion, the red blood cells were 2,832,000, and haemoglobin 45 per cent. By syringe-cannula method 860 c.cm. of blood was transfused; a rigor followed at once, and lasted fifteen minutes. On January 18th the red blood cells were 4,600,000, and haemoglobin 60 per cent. Following this the condition improved, and on February 1st a small localized empyema was opened, and the right ankle thoroughly cleaned and drained. By February 16th the patient was rapidly convalescing; the sputum ceased to be fetid soon after the abscess was drained. He was evacuated to England on this date.

REFERENCES.

- ¹ H. S. Satterlee and R. S. Hooker, *Surg., Gynec. and Obstet.*, 1914, xix, p. 235. ² Edward Lindeman, *Amer. Journ. Dis. Child.*, July, 1913, p. 28. ³ P. Rous and J. R. Turner, *Journ. Amer. Med. Assoc.*, June 12th, 1915, p. 1980. ⁴ H. S. Satterlee and R. S. Hooker, *Journ. Amer. Med. Assoc.*, February 26th, 1916, p. 618. ⁵ L. J. Unger, *Journ. Amer. Med. Assoc.*, February 13th, 1915, p. 582. ⁶ L. B. Robertson and A. Brown, *Blood Transfusion in Infants and Young Children*, *Canadian Med. Assoc. Journ.*, April, 1915.

A SIMPLE TECHNIQUE FOR INTRAVENOUS INJECTIONS IN INFANTS.

By ANN MARTIN, M.D. CORNELL UNIVERSITY.
(From the Sick Children's Hospital, Edinburgh.)

ON account of the small size and inaccessibility of the superficial veins in young infants, it is usually difficult, and often impossible, to give intravenous injections or even to obtain sufficient blood for the Wassermann reaction by the methods ordinarily employed. The difficulty is satisfactorily overcome by puncturing the superior longitudinal sinus through the anterior fontanelle, according to the procedure recently introduced by Helmholtz of Chicago.¹

I have made extensive use of Helmholtz's method in Dr. Fowler's ward in the Edinburgh Sick Children's Hospital during the past winter, and have found it simple and free from risk. The results of saline injections given in this way have been altogether better than those of the subcutaneous method hitherto employed. The following description of the technique of the Helmholtz method, based on a series of 50 cases, is offered as a guide.

The scalp over the anterior fontanelle is shaved and disinfected with iodine. No anaesthetic is required. The child lies in bed with its head raised to a convenient angle on two pillows. A nurse holds the head securely with a hand on either side; the operator stands in front and on the right side of the child. The needle (held at an angle of about 50 to 60 degrees with the plane of the fontanelle)

is inserted in the middle line, half way between the anterior angle and centre of the fontanelle. Some little force is required to push the needle through the firm pericranium, and, when the resistance is overcome, one can feel that the point of the needle is in a cavity. The point should not penetrate more than one-eighth of an inch below the surface of the skin since the sinus lies immediately under the pericranium. If the needle is in the sinus blood flows at once into the syringe; should this not happen the needle has gone too deep, and has passed completely through the sinus. This is the mistake usually made by a beginner; it does not, however, cause any damage. It is rectified by gently withdrawing the needle until the point re-enters the sinus, as is shown by a flow of blood into the syringe.

A specially ground needle is essential. The sinus is in many cases so shallow that an ordinary long-pointed needle pierces the inner wall before the entire opening in the end of the needle is through the pericranium. A needle of size No. 20 or thereabouts, with a bevel measuring 2 mm., should be chosen in place of one with an ordinary bevel, which measures about 4.5 mm.

When introducing fluid, such as eusol or saline solution, we have found a two-way stopcock and 10 or 20 c.cm. syringe, as described by Graham,² the most satisfactory instrument. The needle is inserted with the syringe only a quarter full of fluid, as it is easier to manipulate thus. Very little pressure is needed to inject the fluid, which, indeed, flows in almost of itself on account of the slightly negative pressure in the sinus. If pressure is needed one may be sure that the needle has escaped from the sinus; usually it has accidentally been pushed in too far. Each time the syringe is refilled it is well, immediately before injecting the fluid, to make sure that the needle is still in position by slightly withdrawing the plunger so as to ascertain whether there is a reflux of blood.

Autopsies on patients in whom, for diagnostic or therapeutic purposes, the sinus had been punctured at intervals of from a few hours to several weeks before death showed that in no case had any injury been done, nor in any case in which this method has been used have any untoward symptoms followed. The advantage of using the superior longitudinal sinus is evident. I have never found it necessary to give an anaesthetic. The puncture causes little disturbance, and infants even fall asleep while the fluid is running in. There is also the very material advantage that repeated injections, if such are necessary, are as easily performed as the first.

REFERENCES.

- ¹ *Amer. Journ. Dis. Child.*, vol. x, September, 1915, p. 194. ² *BRITISH MEDICAL JOURNAL*, May 6th, 1916.

ACUTE GENERAL HAEMORRHAGIC PERITONITIS.*

By ARTHUR J. NYULASY, M.R.C.S.ENG.,
GYNAECOLOGIST TO THE PERTH HOSPITAL, AUSTRALIA.

ACUTE general haemorrhagic peritonitis is an uncommon condition, but three cases have come within my experience in the Perth Hospital. Two of them resulted from criminal abortion and came to the *post-mortem* table; one of them presented a striking lividity of the skin, which persisted after death; it involved the whole body, and was so pronounced in the face as to be almost startling. The third case will be described in detail.

A multipara, aged 30 years, transferred from a medical ward, had been admitted with severe diarrhoea and some pain and tenderness in the lower abdomen, the pulse being 120, respirations 32, and temperature 101.9° F. The diagnosis suggested by the physician who sent her to hospital was "ruptured ectopic gestation." In a few days the diarrhoea ceased, and the temperature, after a fluctuating course, dropped to normal, the pulse to 108, and respirations to 28. On then examining the patient I found the tongue clean and moist, the colour of the face normal, and nothing in her appearance to suggest serious illness. The abdomen conveyed the idea of general "fullness," although there was no marked intestinal distension, while the pelvic area, especially in the left iliac fossa, was very tender on pressure. Bimanually a pelvic mass was made out, and later found to be the somewhat enlarged uterus and an enlarged left Fallopian tube and adherent intestines. The mass was extremely tender on pressure, so that a satisfactory examination

* Paper read before the Western Australian Branch of the British Medical Association.