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REACTIONS FROM THE TRANSFUSION OF PRESERVED BLOOD EXPERIENCE WITH 1,600 TRANSFUSIONS

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The convenience of using preserved blood for transfusions was first demonstrated by Robertson (1918), working at the casualty clearing stations of the Third Army, B.E.F., in 1917-18. He collected and stored blood during periods of inaction at the front and administered it during rush times, utilizing the blood-dextrose-citrate mixture which had been devised by Rous and Turner (1916) of the Rockefeller Institute. Subsequent experience in the practice of civil medicine in Russia, France, Great Britain, and the United States of America, and in the treatment of the wounded in the recent war in Spain, has confirmed and amplified Robertson's original observations as to the expediency of this procedure.

There remain, however, two basic questions regarding the use of preserved blood: first, Is transfusion of such blood more dangerous than the use of fresh blood?; secondly, Is stored blood therapeutically as efficacious as fresh blood? In this report an attempt is made to answer the first question by a study of the types and incidence of reactions occurring in a series of approximately 1,600 blood transfusions.

Organization of "Blood Bank"

The Blood Transfusion Laboratory of the University Hospitals was organized in September, 1938, after preliminary studies in the laboratory with various methods of blood preservation. The principle of the "blood bank" evolved at Cook County Hospital in Chicago (Fantus, 1937; Fantus and Schirmer, 1938) was adapted to local conditions. The relatives and friends of patients who volunteered as donors were taken to a specially equipped room, where the blood was collected by members of the laboratory staff. The blood was typed by technicians, and specimens were subjected to the Wassermann and Kahn tests. The blood mixtures were stored in a refrigerator at 3° to 5° C. When a patient required a transfusion his blood group was determined and both plasma and cells of the prospective recipient were cross-matched with those of a blood mixture in storage. If the bloods were compatible the proper flask was delivered to the intern in charge of the patient and he administered the blood mixture intravenously. The urine of the recipient was tested before transfusion and,

if found to be acid, sodium bicarbonate was administered orally until the urine was alkaline before the transfusion was performed. However, this procedure was not practicable in emergencies. Within twenty-four hours after transfusion a member of the laboratory staff visited the patient to determine whether a transfusion reaction had occurred, and performed chemical tests for haemoglobin on the twenty-four-hour urine specimen passed after transfusion. If there had been a severe reaction of any type, tests for groups and cross-matching were repeated.

Collection of Blood

The donors who were accepted were healthy adults of either sex between the ages of 16 and 60. They were questioned specifically for a history of venereal disease, malaria, and allergic manifestations. They were not allowed to give blood if suffering from the slightest upper respiratory infection. This precaution was employed so that the subsequent course of such a disease could not be ascribed to loss of blood. No donor was accepted who was suffering from active manifestations of allergy, although the blood of persons having hay-fever was used when drawn during the months when they were free from symptoms. At least three hours must have elapsed since the donor had eaten before the blood was drawn. No donor was allowed to give more than 500 c.cm. of blood in two months.

The collecting apparatus consisted of an Erlenmeyer flask of 1,500 c.cm. capacity in the mouth of which was a two-holed rubber stopper. Short glass tubes were fitted into the holes of the stopper. The outer end of one glass tube was attached to a length of rubber tubing connected to a rubber suction-bulb containing a valve. The other glass tube was connected by means of a short gum-rubber tube to a glass adapter which fitted into a needle. After the apparatus was assembled the sterile solution of sodium citrate was aspirated through the needle and rubber tubing and into the flask, and the tubing was pinched off until the needle was inserted in the vein. This minimized the tendency to clotting which occasionally occurred in the collecting-tube. The flask was calibrated with a scale on the side so that the volume of blood mixture could be measured. When the dextrose-citrate mixture was used the dextrose solution was autoclaved in the collecting-flask.

The donor assumed a supine position on an examining table with the arm supported in abduction by an arm rest. The antecubital fossa was cleansed first with tincture of iodine and

secondly with 70 per cent. ethyl alcohol. A tourniquet was then applied. (The cuff of a sphygmomanometer inflated to a pressure of 40 mm. Hg was found to be more comfortable than the usual knotted rubber tube.) The skin and tissues about the median basilic vein were infiltrated with 2 per cent. novocain through a small needle. When anaesthesia was obtained a needle of large calibre (16 gauge) was inserted into the vein and the blood allowed to flow through the rubber tubing and into the preservative mixture in the collecting-flask. Moderate suction was applied by means of the rubber bulb containing the valve. The blood was mixed with the preservative solution by rotating the collecting-flask gently in the horizontal plane. At the conclusion of the operation the rubber stopper in the collecting-flask was replaced by a sterile plug of cotton-wool and the flask was immediately stored in the refrigerator after a 20-c.cm. sample of blood mixture had been pipetted aseptically into a small pilot flask. The latter container was also placed in the refrigerator and the contents used to cross-match with the blood of prospective recipients, thus obviating the necessity for opening the large flask before transfusion.

One important precaution was found necessary when collecting blood in the dextrose-citrate mixture, to be described later. It was discovered that this preservative solution should be very cold (just out of the refrigerator) when the blood was run into it, otherwise intense haemolysis often occurred within a few hours after collection. It was demonstrated that the erythrocytes swell when suspended in dextrose solutions, and are thus more vulnerable to further osmotic changes induced by contrasts in temperature in various parts of a large volume of blood mixture being cooled.

Preservative Mixtures

Two types of mixture were used. One consisted of 500 c.cm. of blood plus 100 c.cm. of 3.2 per cent. dihydric sodium citrate ($\text{Na}_2\text{C}_6\text{H}_5\text{O}_7 + 2\text{H}_2\text{O}$) in water. In this case the citrate solution was autoclaved in a small flask and aspirated into the collecting-flask through the needle and rubber tubing just before drawing blood.

The other preservative was a modification of the original mixture of Rous and Turner (1916). Those workers had used 500 c.cm. of blood mixed with 350 c.cm. of isotonic sodium citrate solution and 850 c.cm. of isotonic dextrose solution. This was admirable for preserving blood, but the content of sodium citrate was so high that it was necessary to discard the plasma and resuspend the cells in saline or gelatin solution before transfusion could be considered safe. Our modification reduced the concentration of citrate and increased the proportion of blood, so that the mixture could be safely given without discarding any part of it. The mixture consisted of 500 c.cm. of blood, 650 c.cm. of 5.4 per cent. anhydrous dextrose in water, and 100 c.cm. of 3.2 per cent. dihydric sodium citrate in water. The two solutions were autoclaved separately to avoid caramelization of the sugar; the dextrose was conveniently autoclaved in the 1,500-c.cm. collecting-flask, while the citrate was sterilized in a small flask and aspirated into the dextrose just before drawing the blood.

The dextrose-citrate solution was adopted because it was found to inhibit haemolysis much better than did citrate or saline-citrate solutions. There was only 1/25 to 1/50 as much haemoglobin in the plasma at the end of thirty days of storage in the dextrose-citrate solution as in the others. The details of these studies have been published elsewhere (DeGowin, Harris, and Plass, 1939, 1940a).

Period of Storage

The time during which blood may be stored and safely used for transfusion depends upon many factors. One consideration is the amount of haemolysis present. It has been shown that haemolysis in preserved blood is progressive and begins immediately upon storage (DeGowin, Harris, and Plass, 1939, 1940a). It is the impression of many writers that the transfusion of large amounts of extracellular haemoglobin is dangerous. The

exact dosage which is toxic and the mechanism of injury are still a moot question, so we have taken as a working hypothesis the assumption that transfusion of enough extracellular haemoglobin to produce haemoglobinuria is undesirable. Accordingly, we have arbitrarily discarded citrated blood after ten days of storage and have used blood in the dextrose-citrate mixture when it has been stored up to thirty days. The data on our transfusion reactions apparently justify these limits as safe.

Another possible danger from the transfusion of blood which has been stored too long has been the high potassium content of the plasma (Scudder, Drew, Corcoran, and Bull, 1939). It is true that during storage some of the potassium of the erythrocytes diffuses into the plasma, but studies in our laboratory (DeGowin, Harris, and Plass, 1940b) have shown that the potassium concentration in plasma approaches a maximum in fifteen days of storage, and transfusion of blood stored for this period has produced no clinical reactions, no increase in the serum potassium of the recipients, and no electrocardiographic changes (DeGowin, Hardin, and Harris, 1940).

Administration of Preserved Blood

When a patient required a transfusion his blood group was determined and his serum and cells were cross-matched with those of a blood of suitable type stored in the refrigerator. The cross-matching was actually performed with specimens from the small pilot flask stored separately from the major portion, so that the latter was undisturbed. The flask of compatible preserved blood was then delivered to the intern, who administered it to his patient. A sterile salvarsan tube of 800 c.cm. capacity was suspended from a suitable support. To this was attached a four-foot length of gum-rubber tubing with glass adapter and needle of 18 or 20 gauge. About 100 c.cm. of sterile 0.85 per cent. sodium chloride solution was first poured into the apparatus and the air bubbles were displaced from the tubing. The needle was then inserted into the recipient's vein and the saline allowed to flow in. In the meantime the blood mixture was gently shaken and poured into the salvarsan tube through a sterile conical wire-mesh filter (about 100 mesh to the inch), upon which were placed several layers of sterile cotton gauze. This effectually held back the small shreds of fibrin and the layer of conglutinated and autolysed leucocytes, which becomes quite tenacious during storage. The blood was allowed to run in by gravity at a velocity of between 5 and 40 c.cm. per minute.

It must be emphasized that no attempt was made to heat the blood mixture before administration. The injection was often begun when the blood was nearly at the temperature of the refrigerator, and no reactions were noted from this procedure. In a separate publication (DeGowin, Hardin, and Swanson, 1940) we have presented detailed studies to show that this practice is harmless and does not lower the body temperature appreciably. This is not only a great convenience, but also saves time in emergencies and excludes possible accidents incurred in attempting to heat the blood (Baker, 1937). It should be particularly useful in the emergencies of military surgery.

The series of 1,604 blood transfusions here reported represent practically all of the operations supervised by the staff of the Blood Transfusion Laboratory from October 11, 1938, until January 19, 1940. The amount of blood given in each transfusion varied from 50 c.cm. for infants to 500 c.cm. for adults. The largest volume

was by far the most commonly used. The total volume of fluid for 500 c.cm. of citrated blood was 600 c.cm. The dextrose-citrate mixture constituted a total volume of 1,250 c.cm. when 500 c.cm. of blood was used. Many recipients received more than one transfusion. The indications for transfusion were chiefly anaemia, serum protein deficiency, infections, and shock.

Influence of Age of Transfused Blood on Incidence of Reactions

Table I contains a detailed analysis of the incidence of various types of transfusion reaction tabulated according to the number of days the blood was stored and the preservative used. The category designated as "0 days" contains the data on 146 bloods which were administered within two hours after collection, and serve here as a control series of fresh blood transfusions.

TABLE I.—Incidence of Reactions from Transfusion of Blood of Various Ages

Days of storage of blood		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	31	36	38	Totals	Per cent. (all ages)	
Dextrose-Citrate Blood	No. of transfusions	7	17	31	50	38	31	20	12	6	11	17	11	10	9	11	13	13	15	8	10	7	6	12	5	4	4	1	3	3	1	1	387		
	Chills only {Number Per cent.	0	0	0	0	0	1 3.2	1 5.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	2	0.5%	
	Chills and fever {Number Per cent.	0	0	0	2 4.0	3 7.8	3 3.2	1	0	0	0	0	0	0	0	0	1 9.0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	6	0	8	2.0%
	Urticaria {Number Per cent.	1	1 5.8	0	0	0	2 6.4	0	0	0	0	0	0	0	0	0	0	0	0	1 6.6	0	0	0	0	0	0	0	0	0	0	0	0	5	1.2%	
	Haemoglobinuria	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3		
	Miscellaneous			a				b	a																					c				4	

Citrated Blood	No. of transfusions	139	132	157	197	152	127	117	73	50	36	25	6	3	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,217	
	Chills only {Number Per cent.	0	3 2.2	4 2.5	2 1.0	2 1.3	3 2.3	1 0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	1.2%
	Chills and fever {Number Per cent.	4 2.8	7 5.3	6 3.7	4 2.0	3 1.9	4 3.1	3 2.5	3 4.1	0	2 5.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	36	2.9%
	Urticaria {Number Per cent.	2 1.4	4 3.0	1 0.6	4 2.0	2 1.3	2 1.5	2 1.7	2 2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	1.5%
	Haemoglobinuria	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
	Miscellaneous				a	d		f		e																								5

Symbols : a, Reaction from injection of distilled water. b, Dyspnoea and cyanosis. c, Death from cardiac embarrassment. d, Asthmatic attack. e, Epigastric pain. f, Death from incompatible blood.

The clinician often has difficulty in differentiating between the chills and fever which may be attributed to a transfusion and those which occur in the course of the primary disease but are coincidental with the injection. In case of reasonable doubt such an occurrence was recorded as a transfusion reaction.

The number of transfusions in some categories is too small to be treated statistically, and the minor variations in the percentage of reactions cannot be regarded as significant. It will be noted, however, that there is no striking increase or decrease in the incidence of reactions with longer storage of the blood. The small difference in reaction incidence from blood in the two preservatives is not considered significant.

Chills and Fever from Blood Transfusions

The occurrence of fever persisting for three or four hours and usually preceded by a chill is the most common type of reaction from blood transfusion. This syndrome is also noted during the intravenous injection of solutions of sodium chloride, dextrose, and other parenteral fluids. The work of Seibert (1925), which has been amply confirmed by others, demonstrated that certain bacteria,

many of them non-pathogenic, could grow in distilled water and elaborate filterable thermostable substances called "pyrogens," which produce transient febrile reactions when injected intravenously into animals or man. Certainly the manufacture of parenteral fluids and the preparation of apparatus for intravenous use with proper regard for the exclusion of pyrogens have resulted in almost complete elimination of febrile reactions in the hands of most workers.

Some hold the opinion that most or all of the febrile reactions occurring with blood transfusions may be due to the introduction of pyrogens. This may be the cause of the majority of reactions, but chills and fever also occasionally occur coincidentally with the appearance of urticarial eruptions and are concurrent with intravascular haemolysis caused by the administration of incompatible blood or distilled water. The role of pyrogens is so well established, however, that whenever blood transfusions

are performed rigid precautions should be taken to exclude them.

When the Blood Transfusion Laboratory was organized provision was made for the control of pyrogenic substances. The water used for the manufacture of parenteral fluids and the cleansing of apparatus for intravenous therapy was distilled in one laboratory and used before there was opportunity for organisms to grow in it. The apparatus for the injection of parenteral fluids was identical with that used for blood transfusions. By requiring a detailed report on reactions from each intravenous injection of saline or dextrose solution it was possible to estimate the percentage of febrile reactions occurring in blood transfusions attributable to pyrogens in the apparatus or in the solutions used with the blood. Table II contains the data covering a period from July 1, 1939, to January 1, 1940. It will be noted that during the months of July and August the pyrogenic reactions from parenteral fluids were relatively frequent and contributed correspondingly to a higher incidence in blood transfusions. It was found that the rubber tubing was being cleansed by washing with pyrogen-free water but was allowed to drain for eighteen hours or more before

TABLE II.—*Incidence of Chills and Fever from Intravenous Infusions of Dextrose and Saline compared with that from Blood Transfusions for the Same Time Period*

Month (1939)	Injections of Dextrose and Saline Solutions			Transfusions of Preserved Blood		
	No. of Injections	Reactions		No. of Transfusions	Reactions	
		No	Per cent.		No.	Per cent.
July ..	1,113	32	2.8	113	7	6.6
August ..	1,185	12	1.0	133	5	3.7
September	1,397	4	0.2	167	7	4.1
October ..	1,210	3	0.2	169	4	2.3
November	1,051	3	0.2	140	4	2.8
December	1,225	0	0	229	8	3.4
Totals	7,181	54	0.75	951	35	3.68

being dried and sterilized. This, of course, offered an opportunity for the formation of pyrogens. When the method of cleansing the tubing was changed so that it was dried immediately by compressed air and autoclaved soon afterwards, the incidence of pyrogenic reactions fell to 0.2 per cent. The incidence of chills and fever in blood transfusions, however, has continued to be about 3 per cent. This could be due to: (1) some peculiarity in the blood itself; (2) the introduction at the time of collection of the blood of organisms which live for a few hours, produce pyrogens, and are then killed by the normal bactericidal agents in the blood; or (3) the contamination of the sodium citrate with pyrogens. We are not prepared to choose between these alternatives at the present time. The first two possibilities seem more likely, since one would expect a higher incidence of reactions if pyrogens were distributed uniformly in the sodium citrate. The dextrose used in the one preservative mixture and the distilled water used in the sodium citrate solution came from the same source, as did that employed for the manufacture of parenteral fluids.

Occasionally a patient had a chill or complained of chilly sensations during the injection of saline, dextrose, or blood, but no elevation of temperature ensued. Although there is no proof to justify it, these reactions have been considered as due to pyrogens and have been so counted in Table II.

Urticarial Reactions

While urticaria and angioneurotic oedema have long been considered to be allergic manifestations it is common experience that the causative allergens in many cases cannot be found. Urticaria or angioneurotic oedema was not reported in the series of 7,181 injections of parenteral fluids, but occurred in 1.4 per cent. of the 1,604 blood transfusions. A history of allergic manifestations was requested of all donors and recipients, but the occurrence of urticaria from blood transfusion could not be correlated with previous experience of allergic symptoms. The high potassium content of the transfused plasma did not seem to be a factor, since the reaction occurred as frequently with fresh blood or that stored for only a few days. The donors had not eaten for at least three hours before the collection of blood. The present study sheds no light on the cause of urticarial transfusion reactions.

One interesting case was observed, however—that of a member of the hospital staff who had had angioneurotic oedema, the allergic cause for which had not been found. Two years later he gave blood to ten different recipients, four of whom developed such severe angioneurotic oedema that the transfusions had to be discontinued.

Haemoglobinuria from Blood Transfusion

In haemoglobinaemia from any cause the extracellular haemoglobin disappears from the blood serum at a rate somewhat dependent on the concentration. Some of it is deposited in the reticulo-endothelial system of the liver and spleen and in the proximal convoluted tubular epithelium of the kidney (DeGowin, Warner, and Randall, 1938). If the concentration of haemoglobin in the serum is sufficient some of the pigment is excreted in the urine. Drabkin, Wideman, and Landow (1935) have shown that only about 10 per cent. of the pigment is disposed of in this manner. Lichty, Havill, and Whipple (1932) demonstrated a renal threshold for haemoglobin in the dog, and more recently Ottenberg and Fox (1938) have shown a similar mechanism in human beings. The relation between haemoglobinuria and the production of anuria is still not settled. The reader is referred elsewhere (DeGowin, Warner, and Randall, 1938) for a discussion of this subject.

There are several possible methods by which haemoglobinuria might result from the transfusion of preserved blood. It has been shown that haemolysis is a steadily progressive process during storage (DeGowin, Harris, and Plass, 1939, 1940a). If enough extracellular haemoglobin is transfused the renal threshold is exceeded and the pigment appears in the urine. This occurred in two patients receiving blood containing respectively 1,665 mg. and 11,840 mg. of extracellular haemoglobin in the plasma. The urine was coloured for a day or so, but no symptoms or jaundice ensued. On the other hand, one patient received 1,822 mg. of free haemoglobin without haemoglobinuria.

The transfusion of incompatible blood may, of course, result in haemolysis, as in the following case:

One patient in our series was a woman belonging to Group O (Type IV Moss) who had received several transfusions of compatible blood without incident. Then through a series of errors in the laboratory she received a transfusion of Group A (Type II Moss) blood. When about 100 c.cm. had been injected she became cyanotic and dyspnoeic, and shock promptly developed. The transfusion was discontinued and a transfusion of 500 c.cm. of Group O blood was administered with only temporary benefit. She died in shock about six hours later. The blood serum and urine contained much free haemoglobin. Post-mortem examination revealed no alternative cause of death.

Another possible method of producing haemolysis is by the transfusion of haemolysins active against the recipient's cells in such high titre that they are not inactivated by dilution in the recipient's plasma. Such an instance was reported by one of us (DeGowin, 1937) in which the transfusion of Group O blood into a recipient of Group AB produced haemoglobinuria. In the present series two patients belonging to Groups A and AB received preserved blood of Group O and excreted haemoglobin in the urine, but showed no other symptoms. The haemoglobin content of the transfused plasma was determined in advance as 1 mg. and 721 mg. respectively. These concentrations were probably too low to have exceeded the renal threshold, so that the above explanation is at least possible.

The introduction of other haemolytic substances at the time of transfusion offers a further possibility. Through a misunderstanding three patients in one ward received transfusions with a preliminary injection of 100 c.cm. of distilled water instead of physiological saline solution. Before the injection of the blood had begun the patients complained of a feeling of constriction in the chest and

dyspnoea. Two of the three had chills and fever. Only slight amounts of the transfused blood were actually given. No haemoglobin appeared in the urine, but doubtless some intravascular haemolysis occurred.

A fifth mechanism for the production of haemolysis from transfused preserved blood theoretically exists. If the erythrocytes during storage lose some of their ability to withstand trauma it might be expected that many would be promptly destroyed by being forced through the capillaries of the recipient. No exact studies have yet been made on this subject, but it can at least be concluded from our series that the breakdown was not sufficient or fast enough to produce haemoglobinuria.

Jaundice

Icterus often occurs in haemolytic reactions involving fresh blood. It is not proved that the jaundice is entirely due to haemoglobin itself, since the van den Bergh reaction is sometimes "direct" within a day after the accident occurs (DeGowin, 1938). Belk, Henry, and Rosenstein (1939) reported several cases of jaundice in 400 transfusions of preserved blood, and Fox (1939) had fourteen cases in 100 transfusions. Leedham-Green (1939) recorded no jaundice in sixty transfusions; Biddle and Langley (1939) had none in 150 cases. Jaundice was observed only once in our series. This occurred in an infant with septicaemia from haemolytic staphylococci. The icterus was observed some fourteen hours after transfusion. Neither haemoglobinaemia nor haemoglobinuria was present. Further tests showed no incompatibility in the recipient's and the donor's blood. From post-mortem examination the pathologist concluded that the icterus was the result of bacterial haemolysis and of cloudy swelling of the liver due to the infection. The disparity in the incidence of jaundice reported by various workers is difficult to explain. It will not be possible to evaluate this situation until the amount of extracellular haemoglobin injected in every case is known. So far this has seemed impracticable.

Embarrassment of Cardiovascular System

Plummer (1936) reported five deaths from pulmonary oedema following blood transfusions in Charing Cross Hospital. One of us (DeGowin, 1938) added two more to the literature. Both of our patients received compatible blood; one had chronic nephritis and the other had subacute bacterial endocarditis. Murphy, Grill, and Correll (1940) in a recent experimental study have shown that the intravenous injection of relatively small amounts of fluid into patients with potential cardiac failure causes increase in the venous pressure and slowing of the circulation time.

In the present series an infant, aged 2 months and weighing $7\frac{1}{2}$ lb., was brought to the hospital because of malnutrition. Through an error 800 c.cm. of blood-dextrose-citrate mixture was injected slowly into the jugular vein in a period of two hours. The patient became extremely dyspnoeic and cyanotic, and generalized anasarca suddenly appeared. The transfusion was discontinued and the respiratory signs abated somewhat. The oedema persisted. Sixteen hours later 50 c.cm. of blood was withdrawn from the fontanelle, with temporary improvement. The patient died thirty-six hours after the transfusion. Post-mortem examination revealed intense engorgement of all vessels, dilatation of the heart, and marked peripheral oedema. There was only slight oedema of the lungs.

Types of Reaction Distinctive of Preserved Blood

From the tabulation reported in this paper it is evident that no types of reaction were observed from the trans-

fusion of preserved blood which were not already known to be associated with the use of fresh blood. It is obvious that the incidence of haemoglobinuria depends to a great extent upon the preservatives employed and the period of storage.

Summary

Data have been presented on the incidence and types of reaction occurring in a series of 1,458 transfusions of blood stored from one to thirty-eight days and 146 transfusions of fresh blood. No types of reaction were encountered that were distinctive of preserved blood. The incidence of various types of reaction did not increase or decrease with the period of storage of the blood mixtures. A limit of ten days of storage at 3° to 5° C. was found to be safe for citrated blood. Blood stored in the dextrose-citrate mixture described was found to be safe for transfusion after thirty days of storage. A comparison of the incidence of pyrogenic reactions in a series of 951 blood transfusions with that in a series of 7,181 parenteral injections of saline or dextrose showed that about 3 per cent. of the febrile reactions from the blood transfusions could not be attributed to pyrogens in the apparatus or fluids used. This comparison did not exclude the possibility of the introduction of pyrogenic organisms at the time of the collection of the blood. The presence of pyrogens should be suspected when the incidence of febrile reactions is high. There were two deaths from transfusions—one from incompatible blood and one from cardiac embarrassment. Neither of these could be attributed to the use of preserved blood in contradistinction to fresh blood.

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Lord McGowan, Chairman of Imperial Chemical Industries, in his presidential address to the National Safety First Association last month, said: "A lost-time accident in a factory should be regarded as much a gain to the enemy as a casualty in the armed Forces." The Government's recognition of the importance of accident prevention is shown by the inclusion of safety as one of the subjects to be covered by the Factory and Welfare Advisory Board of the Ministry of Labour and National Service. Industrial accidents constitute a serious brake on production to meet the needs of war. Speeding up of processes and a huge influx of new and untrained employees into industry have enormously increased the risk of accidents. There has been a heavy crop of minor casualties, accompanied by an unduly high proportion of septic cases due to failure, especially of new workers, to realize the importance of immediate and proper first-aid treatment. The Industrial Welfare Society and the National Safety First Association (52, Grosvenor Gardens, S.W.1) provide a joint accident prevention service for industry. The latest addition is a booklet specially designed to draw the attention of new employees to the fundamentals of works safety.