

Military Medicine and Surgery

TRANSFUSION WITH TESTED BLOODS

INCLUDING THE GROUPING OF ONE THOUSAND BLOODS
AND A METHOD FOR USE AT ADVANCED
HOSPITALS *

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In military hospitals the indications for direct transfusion of blood, namely, hemorrhage, shock and prolonged infection, arise with considerable frequency. I do not wish to enter into a controversy over the value of transfusion in these various conditions, but will point out the value of the laboratory as an aid to conducting the operation without accident. It is well known that the use of indiscriminately selected donors may nullify the value of transfusion, or even be disastrous to the recipient, and it seems to be the case that accidents of this sort are more frequent in the base hospitals than in those nearer the front. The reason for this difference is not altogether apparent, but the patients at the base have been wounded for a longer period and have been drained by infection to a greater degree than those nearer the front. The fundamentals of this problem must be the subject of further investigation. In this base hospital of about

TABLE 1.—BLOOD GROUPS *

Cells of Groups:	Serums of Groups			
	1	2	3	4
1	—	+	+	+
2	—	—	—	+
3	—	+	—	—
4	—	—	—	—

* The plus sign indicates agglutination and hemolysis. It will be seen that this grouping of Lee is the opposite of that of Ottenberg and others.

1,200 beds, transfusion has been practiced forty times with properly tested bloods. In two instances, reactions were noted in the recipients, one being due to a confusion of names of donors, whereby the donor's corpuscles were agglutinated by the recipient's serum, the other being a case in which the recipient's cells were agglutinated by the donor's serum. In both cases the reaction appeared after the introduction of about 50 c.c. of the donor's blood, and the operation was immediately stopped. In neither case was the reaction fatal.

METHODS

Two methods of testing the blood have been used in this laboratory. The method of Kolmer as outlined in Webster's "Diagnostic Methods" was employed in fourteen cases. From a purely laboratory standpoint, this method was satisfactory and accurate, but was found to occupy a longer time for attaining results than the surgeons considered desirable. It cannot be completed in less than two and one-half hours, which means a great delay when the wounded and infected patient is suffering from a severe secondary hemorrhage. Hence the method of Lee¹ was welcomed and used with great success. This is based on the fact, long known, that the interaction of serum or plasma and red corpuscles places every individual in one of four groups, as in Table 1.

* Aided by a grant from the American Red Cross.

1. Lee, R. I.: A Simple and Rapid Method for the Selection of Donors, Brit. Med. Jour., 1917, 2, 684.

Any of the standard methods for demonstration of agglutination may be applied, but that recommended by Lee appears to be the simplest and quickest. For this test it is necessary to have the serums of individuals of Groups 2 and 3; a sufficient amount of these for establishing the method was kindly provided me by Major Lee. A platinum loopful of each of these serums is placed on a clean microscope slide, and to each is added either an equal amount of whole blood, or blood placed in 1 per cent. sodium citrate solution or in physiologic sodium chlorid solution. In reading the agglutination, care must be taken not to confuse rouleaux formation for agglutination. In this laboratory the routine of the test is carried out in the following manner:

From 0.5 to 1.0 c.c. of 0.85 per cent. sodium chlorid solution is placed in a small test tube, into which are dropped 2 drops of the blood to be tested. If a clot forms, a satisfactory emulsion of cells can be made by shaking the tube. A platinum loopful of each of the standard serums is placed on a clean slide, and into each drop a loopful of the blood emulsion is rubbed. The reading of the agglutination is made under the microscope (16. mm. objective) and is usually complete in from five to fifteen minutes. As will be seen from the table, if both drops show agglutination, the blood is in Group 1; if neither shows agglutination, it is in Group 4; and if one shows agglutination and the other not, the blood belongs to the group in which there is no agglutination. A somewhat smoother emulsion may be made by inverting the slide so as to convert the drops into hanging drops. The inverted slide can be placed on the microscope stage on another slide whose ends are built up with small pieces of fairly thick slide pasted on with balsam. We frequently use a Group 4 serum as a control. The reaction is so sharp that it is easily read; and if a microscope is not available, a lens of 10 diameters magnification will be quite ample in the hands of a trained worker; and the tests should be carried out by a properly trained man. Reports can usually be handed to the surgeon in fifteen minutes.

A large list of available donors may be grouped in this fashion, so that when a patient needs a transfusion, his blood may be quickly grouped, and a donor selected from the list posted either in the laboratory or the operating theater. Donors should be free from infectious disease, particularly syphilis.

It can readily be seen that if a donor is used in the same group as the recipient, the cells of neither will be agglutinated or hemolyzed. Lee maintains, however, that if the donor's serum, according to in vitro experiments, agglutinates the recipient's cells, such donor may be safely used because the donor's serum is thus diluted from five to twelve times, and in addition, the recipient's cells are "amply protected by his own serum," presumably because of the presence of some antiagglutinative substance. Conversely, if the donor's cells are agglutinated by the recipient's plasma, reactions appear which may be so severe as to be fatal, and at best such a transfusion would be of no value because the agglutinated cells are finally hemolyzed.

If these statements are true, Group 4 donors may be used for any transfusion, as their cells are not agglutinated by the serum of any group. In the same manner, Group 1 may receive blood from any donor, as the serum of Group 1 does not agglutinate any cells. While feeling sure that Group 4 may be used as the "universal donor" with almost complete safety,

I prefer to use donors in the same group as the recipient when possible, because of my observation of one unfavorable case in which a reaction appeared, the test having shown that the donor's serum agglutinated the recipient's cells as demonstrated by the method of Kolmer. It also appears to me that the protection of the recipient's cells from agglutination by the donor's plasma is probably the result of an anti-agglutinative body rather than because of dilution, for it can be shown that serum retains its agglutinative properties when diluted as much as thirty-two times. Naturally such an antiagglutinative body would operate better against a diluted plasma than against an undiluted plasma. The problem is further complicated by the variable agglutinability of cells from different individuals. The patient worn down by infection may possibly be less resistant to such agglutinative serums than the freshly wounded man. If standard serums are not obtainable, Lee recommends the following method as the minimum procedure for testing.²

A small amount of blood is collected from a patient (1 c.c. from the ear or finger is sufficient), and allowed to clot. The serum is then obtained. One drop of this serum is placed on a slide and mixed with a drop of a suspension of blood of the donor taken into 1.5 per cent. citrate solution. (A few drops of blood are taken into approximately ten times the amount of 1.5 citrate solution and shaken. It is very important that the blood be dropped directly into the citrate, and should not be partially coagulated.) The test will appear in a few moments, and is best examined under the microscope, where, in the event of a positive test, marked agglutination will be evident. The test will also be evident macroscopically. In the event of a negative test it is a wise precaution to raise the cover glass, and after making sure that the serum and cells are well mixed, to examine the preparation again. The only possible source of confusion is the appearance of rouleaux of the red corpuscles, indicating a too thick emulsion. If the test is negative, transfusion may be regarded as entirely safe.

PERCENTAGE DISTRIBUTION OF GROUPS

The figures with which I am familiar are based on a relatively small number of observations. Statistics of this sort naturally increase in accuracy with the number of observations. As a large number of soldiers could be examined, the bloods of 1,000 individuals were subjected to examination with the results given in Table 2.

TABLE 2.—CLASSIFICATION OF BLOOD IN ONE THOUSAND CASES

	Per Cent.
Group 1	3.1
Group 2	42.4
Group 3	8.3
Group 4	46.2
	100.0

Granting that Group 4 is the universal donor, the chances of a member of any group having a suitable donor in case the blood is not tested are as indicated in Table 3.

TABLE 3.—CHANCES OF HAVING A SUITABLE DONOR

Group 1	493 in 1,000
Group 2	886 in 1,000
Group 3	545 in 1,000
Group 4	462 in 1,000

If the group percentage in each group is multiplied by the favorable chances of that group expressed as

2. At the time of writing this paper I was not familiar with the method of Rous and Turner which is superior for places not equipped with the standard serums (Rous, P., and Turner, J. R.: A Rapid and Simple Method of Testing Donors for Transfusion, *THE JOURNAL A. M. A.*, June 12, 1915, p. 1980).

fractions of 1,000 and the results added, the total gives the chance of any individual having a successful transfusion, if the bloods are untested. This figure is 649 in 1,000. I am indebted to Lieut. W. B. Rogers of the Lakeside Unit for perusal of his notes on a series of transfusions with untested bloods at a casualty clearing station in order to determine how closely the theoretical figure 64.9 per cent. approximates the chance in actual practice. Ruling out thirteen cases, the notes of which are not complete owing to the rush of work, and ten cases which were hopeless at the start, there are thirty-six cases, of which ten showed reactions varying from a slight chill to severe rigor, or 73 per cent. without reaction of any kind.

TESTING AT ADVANCED HOSPITALS

The first point behind the lines at which transfusion is practicable is at the casualty clearing stations, or evacuation hospitals. Frequently such a station may have no laboratory of its own, but may be served in conjunction with several others by a central laboratory. It is obviously impossible to test recipient's blood in need of immediate transfusion if the laboratory is several miles away. It is possible, however, to test prospective donors, send the results to the hospital, and use Group 4 as the universal donor. Delay in transportation of the blood to be tested is of little importance, and we have found that blood taken into salt solution and kept at room temperature will retain specific agglutinability for seventeen days, in spite of the appearances of distinct hemolysis in the tubes. If considered desirable, it would be possible to test donors at the central laboratory, and have recipients tested at the casualty clearing stations, thus preventing the use of only Group 4 donors.

For purposes of testing at the casualty clearing stations, it was at first thought that the stations could be provided with slides on which were dried drops of the necessary serum; but it was found that after drying for several days, the serum was not easily redissolved, and when redissolved, it had lost its agglutinating power. Supplying the stations with ampules of serum was not considered desirable because of the difficulty in keeping the serum free of infection. In order to overcome these difficulties, it was decided to provide the "resuscitation teams" with serum in tubes, drawn out of glass tubes, similar to those in which glycerinated vaccine virus is provided. If desired, the serum may be preserved with 0.5 per cent. phenol (carbolic acid), for we have determined that this does not alter the titer of the serum, and that it agglutinates powerfully for at least a month after being phenolated and remaining at room temperature. Accordingly, a team has been sent to a casualty clearing station with this equipment:

- Six microscope slides.
- Six tubes, 75 by 10 mm.
- Fifty small tubes of Group 2 serum.
- Fifty small tubes of Group 3 serum.
- One copper wire loop (platinum and aluminum not being available at the moment).
- One hand lens of 10 × magnification.

This can be packed in a tin such as carries 100 cigarettes, and is thus easily transportable. The serum is blown from the tubes directly on the slide, and an equal amount of blood is suspended in physiologic sodium chlorid solution, rubbed in with the loop. The slide is inverted, stands at room temperature for ten minutes, and the result is read with the hand lens.

The loop must be dried with a towel or blotter in going from one serum to the other, but does not necessarily need sterilization. As the serum is exhausted, a new stock can be forwarded; but because of the chance of deterioration when kept at room temperature, it is well not to send too great a stock.

This method has been found to be entirely satisfactory in the hands of Lieuts. B. F. Harrison and W. R. Barney; but any method for use at a casualty clearing station presupposes a firm conviction on the part of the operators that testing of the blood is of fundamental importance. It is highly desirable that the surgeon undertaking the procedure be familiar with general laboratory technic and that he has seen the test carried out by some experienced person.

THE BRITISH ZONE OF THE ADVANCE

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GENERAL CONSIDERATIONS

It may be stated as a truism that any comparison between the French and English methods of treatment or evacuation of the wounded in their respective zones of advance is impossible, because of radical differences in the topography of the land and in the general conception of trench warfare.

The English have maintained a comparatively short front, difficult to hold and correspondingly more difficult to advance in. They have pinned their faith in density of front, with continuous activity along the entire front, alternating with intense attacks in selected sectors. The enemy, constantly and diligently harassed, retaliates in kind; the pressure is constantly maintained, night and day. This unending "strafing" has naturally multiplied the problems of evacuation, increased the distance between the front lines and the regimental aid posts, and lengthened the elapsed time between the reception of a wound and its thorough surgical treatment. The evacuation hospitals or casualty clearing stations (C. C. S.'s) are under more or less constant bombardment, either by large caliber naval guns or aeroplane guns (Archies); they have frequently had to be moved about from place to place, and it has been impossible to keep the wounded in the zone of the line of communications until their wounds are healed.

The inevitable result has been that the British base hospitals have had to perform a good percentage of primary operations and a still larger percentage of secondary or completing operations.

Primary closure of wounds, after thorough excision of all devitalized tissues, which is now almost an axiom in the French army, is still in the experimental stage with the British (January, 1918). This apparently radical difference in the zone of advance should not be laid at the door of conservatism; rather is it due to the time element, the extremely precarious position of the casualty clearing stations, and the consequent necessity of rapid evacuation of the wounded men to the base.

An advance research hospital has lately been established in one of the casualty clearing stations for the purpose of testing out the possibilities of primary or

primosecondary closure of wounds. The results are very encouraging and will, no doubt, lead to a gradual adoption of the French method. Every effort is made to get the wounded to the casualty clearing stations while the wound infection is still localized; stretcher bearers and ambulance drivers are straining every effort toward expediting evacuations, working under surroundings of almost indescribable difficulties.

TOPOGRAPHY OF THE LAND

The salient that I visited forms part of the plain of Flanders, the gentle slopes affording no protection from enemy visibility. The rainfall is always very heavy, and the constant presence of surface water makes trench digging impossible. The principal city is a mass of ruins, and the few scattered villages in the two sectors visited have entirely ceased to exist.

For miles in every direction, there is hardly a square yard that is not represented by a shell hole, full to the brim of muddy water. The mud, a mixture of clay and sand, is treacherous to the extreme; men have actually disappeared, as though swallowed up in quicksand. Roads are either under constant shell fire or have been entirely destroyed as one approaches the front lines. Consequently all movements of troops, as well as the evacuation of the wounded, take place along the "duck-board" paths laid on posts driven in the mud. Bodies of horses and men lie, unburied, in shell holes, polluting water and soil and filling the atmosphere with a stench that seems at times almost unbearable. Trenches being impossible to construct or maintain, on account of the mud and water, the men in the front lines are forced to crouch in shell holes from which the water is bailed or pumped out. The only relative protection against shell fragments is afforded by the "pill boxes" which the enemy had constructed when he held that part of the sector. These pill boxes are ferroconcrete mitrailleuse forts, approximately 20 feet square and 8 feet high in the interior chamber. The British use these for regimental aid posts or relay stations for stretcher bearers.

A duck-board path is usually 3 feet wide and from 1 to 3 feet above the mud and water. Attempts have been made to build them double or even triple width, in order to evacuate the wounded on two wheeled stretcher carts; but the experiment has, so far, not been very successful owing to greater exposure to shell fire. In order to avoid enfilading fire they are always built zigzag, direction being changed about every 20 yards. A special evacuation line, 4 miles long, was built; but, owing to the density of troop movements, this path has to be utilized by fighting units as well as by noncombatants, so that the congestion is often very great.

A few narrow gage railroads extend to within 2,000 yards of the front lines, but they are so frequently destroyed by shell fire that the Medical Corps has not seen fit to utilize them for purposes of front line evacuations.

From military, sanitary and surgical points of view, it is impossible to conceive of a more stupendous task than the one confronting our allies in this sector. It is unbelievable until one has actually visited it from front lines to zone of communications; it is equally impossible to describe its horrors after one has seen it. One cannot help feeling unbounded admiration for the bulldog tenacity, courage and spirit of self-sacrifice which alone have enabled the British army to "hang on" to this salient for almost four years and to