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TRANSFUSION, INFUSION, AND AUTO-TRANSFUSION; THEIR COMPARATIVE MERITS AND INDICATIONS.*

BY AUGUST SCHACHNER, M. D., PH. G.

Whenever a number of measures of a more or less varied and changeable character are advanced for the fulfillment of a long-existing demand, it means an absence of unity in the selection of the proper measure and a general distrust in a satisfactory adjustment of the demand. This is clearly illustrated by the number of measures that from time to time have been recommended to overcome the depressing and even fatal condition following enormous hemorrhages.

The fact that the operation of transfusion is but rarely performed at the present time, and that of infusion faring but little better, has tempted me to refreshen the subject, somewhat more than a month ago, before one of our local societies. Since that time I have been impressed more than ever with the neglect to which these operations have been subjected and the importance of bringing them vividly before the eyes of those engaged in operative work.

I may be pardoned for borrowing from my former paper the historical outlines in connection with the development of these minor operative procedures. The first intimation of transfusion can be found in 333d and 334th verses of the seventh book of "Ovid's" *Metamorphoses*, "*Veteremque haurite cruorem ut repleam vacuas juvenili sanguine venas.*" This carries us back to the time of Christ, and from thence down to the present period a long but unbroken chain can be traced running through the Hebraic and Egyptian medical records.

In 1492, or more than a hundred years before the circulation was understood, Pope Innocenz VIII was struggling with his last illness. He was attended by a Jewish physician who, it is supposed, was prompted by the idea noted in the verses of "Ovid," and performed transfusion with the blood taken from three Roman youths. In 1615 Andreas Libavious, of Halle, wrote an article upon a charlatan who is supposed to have performed transfusion. In 1628 another appeared under the authorship of Johann Colle; coupled with these came the discovery of the circulation by Harvey, which was directly responsible for the vigorous attention which the learned men at that time gave to the subject.

In 1652 an apparatus for arterio-venous transfusion was contrived by Folli, of Italy. In 1666 Richard Lower drained a good-sized dog by tapping the jugular vein. When the animal was exhausted he filled the vessels with blood drawn from a cervical artery of a second dog until the animal had recovered, he then drained the same animal a second time and again filled his arterial system with blood from a third dog, thus completely changing the blood twice in the same animal without any unfavorable consequences. This represents the first well-authenticated experimental maneuver made in the direction of transfusion.

* Read at the June meeting of the Kentucky State Medical Society, 1896.

This aroused an interest in the "Royal Philosophical" Society, and it was then believed that a remedy had been discovered, which was not only capable of curing diseases but by means of which the aged could be transformed to the youthful, and the immoral could be changed to the moral. So strong was the belief in the latter that a trial was actually undertaken by Lower and King.

At that time a thirty-year-old religious fanatic, by the name of Arthur Boga, offered himself, in consideration of a guinea, as willing to undergo the experiment, which was conducted in the presence of the Bishop of Salisbury and a large and brilliant audience by Lower and King. Six to seven ounces were withdrawn and ten ounces of arterial blood from a sheep was injected. This operation was again successfully performed on the twelfth of December of the same year by the same operators.

It must be noted, however, that these experiments were preceded by others performed by Jean Dennis and Emmerez in Paris in the year 1667, and to whom the honor of the first successful transfusion upon a human subject is due. Dennis employed the blood of a lamb, and several times repeated the operation upon several different subjects with almost uniform success so far as the transfusion was concerned. These operations aroused a vigorous and jealous opposition in Germany, France, and Italy, and were partly terminated when Dennis narrowly escaped a trap that had been set for him; but notwithstanding his innocence it had involved him in a criminal case.

From this time the enthusiasm began to lag and matters continued with a varied interest until 1818, when James Blundell, the obstetrician, placed transfusion upon a scientific basis, at the same time giving a method for its correct performance. To Blundell is likewise due the honor of first employing human blood instead of that of lower animals for the transfusion. With this the history of transfusion can be dismissed. In parting we might add that there are but few procedures known to medicine whose histories are more replete with incidents that are as varied, interesting, pathetic, and amusing as the history of transfusion.

Before entering upon the subject of transfusion it is well to glance at the conditions which are produced by the loss of large quantities of blood. In dangerous hemorrhages death may ensue from one of two causes, either from the absolute loss of blood itself or from a fatal reduction of the intravascular pressure. In the first instance the amount of blood is insufficient to meet the demands necessary for the sustenance of life. This makes the case unmistakably clear, and the indications are more blood, or death must ensue. In these cases nothing short of transfusion will fulfill the requirement; fortunately, however, these constitute the minority. In the majority of cases the death following hemorrhage is not due to the direct loss of blood itself, but rather to a disturbance in the mechanism of the circulation. Let us glance at the physiology of the circulation.

Two factors must be considered: First and foremost, the force of the heart, and second, the elasticity and contractibility of the arteries. If the heart has an insufficient volume of blood, or perhaps, more prop-

erly speaking, of fluid—for blood is not absolutely necessary for this feature—there is an irregularity in its contractions and a serious crippling in the proper working of its valves, and in consequence we have a condition at once produced which for the time being can be compared to the worst variety of valve lesion, so that the heart not only fails in sending out the required amount for the proper nutrition but also for the closure of the valves. Aside from this the amount of blood sent out is not sufficient to produce the necessary dilatation by means of which the elastic nature of the large arteries are enabled to propel the force of the heart to the more distant parts of the body.

When this state of affairs exists the indication for an increase of the intravascular pressure is equally plain, and the requirement then is more fluid; whether that be blood or salt solution is immaterial.

Transfusion. By transfusion we mean the injection of the blood of one individual into the vessels of another. Although this operation has been variously designated by different writers as both safe and unsafe, there can be no doubt that in the hands of a careful operator all possible elements of danger can be readily eliminated.

Indications. From the history of transfusion it is apparent that formerly its range of application was far more extensive than its merits justified, and in view of this state of affairs the disappointments naturally were quite frequent. This largely aided in relegating it to the disuse to which it was subjected. At present any factor may serve as an indication for transfusion which reduces the quantity of the blood so that the remaining volume is unable, either by reason of the reduction or incapable by reason of any alteration to which it may have been subjected, to carry on the functions necessary for the sustenance of life. The principal conditions which such a statement would comprise, would be either an acute anemia dependent upon an extensive hemorrhage or a paralyzation of the oxygen carrying power of the red corpuscles by carbonic oxide or other similarly toxic gases. We would scarcely still regard such conditions as morphine or atropine poisoning, leukemia, chlorosis, and a host of other pathological states as justifiable indications for the employment of transfusion.

Modus Operandi. There are a few practical features in connection with the operation of transfusion which deserve special attention. During the cholera epidemic of 1866 Von Graefe raised the question as to whether the centrifugal should be given the preference over the centripetal method. Whether it would be better to inject the blood into the arteries rather than into the veins? The advantages urged in support of the centrifugal method were that since the capillaries intervened between the arteries and veins, the blood in its passing through the capillaries was subjected, as it were, to the influence of a strainer which safely withheld any air or emboli which might be present in the transfused blood, the arteries which were employed being either the radial, tibial, or even the brachial. Although this method has the indorsement of Billroth, Heuter, and others, it has likewise many very able opponents who have pointed to the force necessary for the centrifugal method, which not infrequently resulted in a rupture of the capillaries with accompanying gangrenous condition.

Another question to be decided is whether or not the blood should be defibrinated and whether we should select the venous or the arterial blood. Referring to the former of these two questions, we are safe to say that the verdict is almost unanimously in favor of the defibrinated blood. It has been said that the integrity of the corpuscle is considerably affected by the defibrination of the blood, but this is almost problematic; at any rate the dangers of a partial or an entire coagulation which attend the use of non-defibrinated blood fully justify the defibrination.

As to the second question, there are reasons why the venous blood is to be preferred to the arterial; namely, the veins are more accessible than the arteries. The tapping of a vein is simpler and is attended with less subsequent danger than accompanies the opening of an artery; besides the blood, although venous in character, rapidly becomes arterialized during the act of defibrination. In addition to these we might ask, should the transfusion be direct or indirect; that is, should the blood pass directly from the vessels of the donor into the vessels of the receiver without any exposure to air? To this we are inclined to say that we believe it to be far safer to employ the indirect method.

The extreme tendency on the part of the blood to coagulation, and the grave result which attends the introduction of even a minute emboli, not to speak of the chances of the introduction of air, even at the hands of a careful operator, makes us hesitatingly declare in favor of the indirect method.

Should the transfusion be undertaken for the relief of a poisoned condition of the blood, such as results from the exposure to carbonic oxide gas, the individual should be subjected to venesection before the transfusion is undertaken. In the performance of the operation no elaborate outlay of instruments is necessary. Two or three bowls, a reversible aspirator, a glass rod, and a scalpel, all of which being in a perfectly aseptic state, will fill the requirements. Every thing in connection with the operation must not only be perfectly aseptic, but must be heated to 105° or 110° F. When all is in readiness the blood is withdrawn from the arms of one or two donors into one of the aseptic bowls, the amount varying from five to fifteen ounces, according to the circumstances of the case. It is rapidly defibrinated by whipping it with a glass rod and then straining through a piece of sterile gauze into an aseptic bowl. This whipping may be carried out for a minute and a half before straining, but still better is to whip it for a minute and strain, whipping it a second time and again straining through a fresh piece of gauze. It is needless to emphasize that the actual operation must be performed within two or three minutes, and that the greatest care must be exercised that all of the air has been forced out of the syringe and tube before the injection is commenced.

Dangers of Transfusion. The possible dangers that may attend the operation of transfusion are phlebitis, sepsis, emboli, and the introduction of air into the veins; from the foregoing, however, all of these can be readily eliminated if the operator exercises care in the transfusion.

Infusion. By infusion we understand the introduction of non-sanguineous fluids into the circulation. Although the popularity of

this measure is out of recent date, its real history, however, can be traced as far back as the year 1677, when Johannes de Muralto, of Zurich, practiced the injection of milk into the vessels of one of the lower animals. The term infusion, however, as applied to-day, carries with it the idea of a salt solution having the same strength as the serum of the blood. The advantages of this operation over that of transfusion are manifold, especially since death in the majority of instances is not due as much to the insufficiency of the remaining quantity of the blood as it is to a disturbance of the mechanism of the circulation. By the use of the salt solution the dangers common to transfusion are all minimized, and especially the danger from emboli is entirely absent. This widens the field of its usefulness, so that the indications for its use are not wholly confined to conditions following alarming hemorrhages, but includes any pathological state attended with a feeble pulse which is dependent upon a diminution of the intravascular pressure which makes it one of our most valuable measures for combating profound shock.

This property of restoring the tone in a shock condition is not entirely due to the increased intravascular pressure, but also to the stimulating influence which the salt solution has upon the heart. This fact, however, has not received the recognition which it deserved, for it has been but a little more than a decade since it has practically received any attention.

In the year 1881 transfusion lost most of its esteem as a life-saving measure in alarming hemorrhages. At this time E. Schwartz published his paper, "*Über den Werth der Infusion Alkalischer Kochsalz Lösung in das Gefäss System bei Acutes Anämie.*" From this time the adherents to transfusion have been leaving that side in favor of infusion, not that the latter can ever completely replace the former in every case, but because it can successfully replace transfusion in most cases, and where such is possible it is always given the preference owing to its greater safety and convenience. In view of these advantages it is proper that we employ the saline infusion in all alarming hemorrhages.

This operation is uniformly followed by an improvement in the circulation. Should, however, the improvement in the circulation last but a brief interval, it is plain that the amount of blood remaining is incapable of carrying on the conditions necessary for life, and then it is evident that transfusion must be performed in addition to infusion.

In addition it has been pointed to by other authors that the saline infusion protects the internal organs from a too rapid and extensive abstraction of their parenchymatous fluids, which nearly always occurs after an extensive hemorrhage.

By saline infusion we mean the injection of a solution of sodium chloride having the same strength as the serum of the blood, that is, 0.6, into the veins of the bloodless subject. Some add to this a trace of sodium hydrate or sodium carbonate, while others contend that this addition is unnecessary and that, should either the carbonate or hydrate exist in proportion more than a trace, their presence would positively become injurious again; others dissolve the salt in a weak saccharine solution, or the infusion has been successfully carried out by Thomas and others with pure fresh milk.

As for the proper performance of infusion there are several features to be observed. First of all, the solution should have a temperature of about 100° F. Again, the infusion must be made with a slow, steady, and not too strong a stream; should too much force be employed there is danger of over distension of the right side of the heart, and in consequence thereof a paralysis may result. Ordinarily sufficient force is obtained by raising the funnel or the vessel containing the solution to the height of an ordinary arm's length; should this convey the solution with too much force, the latter can easily be regulated by lowering the container to the desired level. As for the quantity to be employed, this must depend upon the nature of the case. In every instance it is not necessary to employ as much solution as the amount of blood lost; all that is required is to inject just enough of the solution to restore the tone of the circulation. Ordinarily, twelve to fifteen ounces can be considered as the minimum quantity to be used for ordinary purposes, but from twenty to twenty-five ounces may be used in alarming hemorrhages. The use of enormous quantities of salt solution should be discouraged, since they dilute the blood to such a degree as to unfavorably influence the red corpuscles.

The operation itself can be divided into three stages: First, the exposure of the vein preferably at the bend of the elbow. This is too well known to require repetition here. In the second stage there is one feature that deserves emphasis, the transfusion tip should only be introduced into the vein while the fluid is running. The observance of this precaution not only washes apart the lips of the opening in the vein, but affords an absolute safeguard against the introduction of any air, which is one of the chief dangers associated either with transfusion or infusion. The third step consists in ligating the punctured vein and applying an aseptic compress.

The principal points in connection with the operation are: To have all steps performed in an aseptic manner, so be careful that the infusion is not made too rapidly, nor with too much force, otherwise there will be danger of overdistending and paralyzing the already much enfeebled heart. Care should also be exercised that too much fluid is not employed, which might give rise to a two-fold danger: First, by the unfavorable influence upon the corpuscles by the dilution of the blood. Secondly, by raising the intravascular pressure to such a degree as to occasion a rupture of one of the smaller vessels in some vital part of the economy. Lastly, it is exceedingly important that great care should be exercised to have the salt solution absolutely free from any minute floating bodies, which if present might act as emboli, producing death or perhaps a gangrene of one of the extremities.

Before dismissing the subject of transfusion and infusion we desire to recall the fact that owing to the extreme cerebral anemia which exists after dangerous hemorrhages, either of these operations can and should be performed without the use of an anesthetic device; in this condition all manipulations are practically of a painless character; and, owing to the enfeebled heart, such operations would only be adding an additional danger.

Auto-transfusion. By auto-transfusion we understand the forcing of

the blood by means of elastic bandages from the extremities to the more vital centers. The indications for this can be summed up as follows: Shock or any condition attended with relaxation and diminished vascular pressure. Again, this is very useful in guarding against accidents in anemic subjects during chloroform narcosis.

In conclusion I beg to submit the following:

1. In enormous hemorrhages the resulting dangers are more frequently due to the reduced intravascular pressure than to the actual loss of blood.

2. In view of this the indications point more decidedly toward infusion than transfusion.

3. That transfusion has not received the attention which its merits justify.

4. In transfusion we possess a measure which in the severest hemorrhages is the only agent capable of restoring the vital functions.

5. The indications for transfusion include any condition which reduces the total quantity of blood to a fatal degree, or which alters the character of the blood to such an extent as to render it incapable of carrying on life.

6. When the transfusion is performed for the relief of a poisoned condition of the blood it should be preceded by venesection.

7. Centripetal is to be preferred to centrifugal transfusion.

8. In centripetal transfusion the injection should be made with a slow, steady stream, carefully exercising no undue force.

9. In withdrawing the blood from the donor the veins afford an easier, safer, and better source than the arteries.

10. Indirect transfusion with defibrinated blood is safer than direct transfusion with non-defibrinated blood.

11. In alarming hemorrhages infusion should be performed before transfusion; should, however, the improvement be transient in its nature, the infusion must be supplemented with transfusion.

12. In addition to hemorrhage the indications for infusion include any pathological state attended with a feeble pulse which is dependent upon a relaxed condition and a diminished intravascular blood pressure, namely, shock.

13. Restoring the tone of the circulation by infusion is not wholly dependent upon the increase of the intravascular pressure, but is in part due to the stimulating influence which salt solution has upon the heart.

14. In performing transfusion or infusion after an enormous hemorrhage the use of an anesthetic is not only unnecessary but absolutely dangerous.

15. In the auto-transfusion we have a valuable measure for combating shock and preventing accidents in anemic subjects during chloroform narcosis.

LOUISVILLE.

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