SUMMARY OF THREE LECTURES

ON

TRANSFUSION:

ITS

PHYSIOLOGY, PATHOLOGY, AND PRACTICE.

Delivered at the Royal College of Surgeons.

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LECTURE I: INTRODUCTORY.

THE first real advance in our knowledge of the physiology of transfusion was made when Leacock in 1817 and Blundell in 1825 drew attention to the marked difference in the result, according as the blood transfused was obtained from an animal of the same species—"similar" blood, or from an animal of another species—"dissimilar" blood. The later researches of Panum, Ponfick, Landois, and others fully established that this difference was due to the poisonous action of the hæmoglobin of dissimilar blood on the organism. The investigations made in recent years have, therefore, had reference more particularly to the behaviour of similar blood, and the fate of its different elements—corpuscles, hæmoglobin, organic constituents of the plasma—after transfusion. As the result of these, much light has been thrown on many important points connected with the physiology and pathology of transfusion; on the importance of proper oxygenation of the blood by Bischoff and Brown-Séquard; on the differences between pure blood and blood after defibrination, and the relative advantages of each for purposes of transfusion by Dumas and Prévost, Martin, Panum, Ponfick, Landois, Hayem, von Ott, Armin Köhler, and others; on the fate of the red corpuscles after transfusion by Panum, Worm-Müller, Hayem, von Ott, myself, and others; on the fate of the organic constituents of the transfused blood by Worm-Müller, Lesser, Tschiriew, and Forster; and, lastly, on the physical properties of transfused blood and of saline solutions by Kronecker and Sander, Schwarz, von Ott, Maydl, and many others.

Nevertheless, the question as to the value of transfusion seems ever to remain an open one, and still retains its interest both for the lay and for the medical mind. The present attitude of medical opinion may be described as one of healthy scepticism. The advocacy of transfusion is left in the hands of a few; and the frequency with which one meets with descriptions of new instruments instead of reports of successful cases may be regarded as lending some colour to the suspicion that even in the minds of these few there is some lurking doubt as to the safety or value of the operation. Much of this hesitancy is traceable to two circumstances. First, that after taking all due precautions, the operator feels himself liable at any moment to be confronted with certain dangers of whose nature he has but imperfect knowledge, and which he is, therefore, not in a position to avoid or confidently grapple with. Secondly, that even when these have been avoided or overcome he is, to a great extent, ignorant of the *rationale* of the operation; he is ignorant how far or in what way his interference has contributed to the result, even when successful; and he cannot explain why the operation fails under conditions that, so far as he can judge, are equally favourable to success.

The problems presented by a study of transfusion are thus partly physiological, partly pathological. The physiological problem is to determine the fate of the different elements of the transfused blood, and to ascertain the functions they severally or collectively discharge in the body of their host. A knowledge of these is essential whether the operation of transfusion is to be advocated or rejected. The pathological portion of the problem is to explain the nature of the disturbances, such as dyspnoea, violent action of the heart, tendency to syncope, and other symptoms, objective and subjective, frequently presented by the patient during the performance of the operation.

Lastly, there always remains the important practical question, What is the value of transfusion and in what conditions is its performance indicated? The answer to this question implies a knowledge of the nature of the changes in the blood in disease, and it is this portion of the problem of transfusion which has hitherto received an attention altogether inadequate to its real importance.

PHYSIOLOGY OF THE BLOOD.

Attention was then directed to some points connected with the physiology of the blood, a knowledge of which is essential to a right understanding of the principles on which transfusion is based.

The ground idea of transfusion is that we are replacing a structure incapacitated by loss or disease for the discharge of its functions by one of similar nature, presumably capable of taking up these functions.

What are the functions of the blood in health, and how is it fitted by structure or composition to discharge them?

The physiology of the blood presents problems of peculiar difficulty, arising from its fluid nature and its close relation to all other tissues of the body—a relationship peculiar to it alone. What is the behaviour of the blood under such circumstances? Its quantity and quality appear to be constantly varying. Are we then entitled to regard it as a tissue at all, seeing that it apparently has no stable composition? When we speak of the blood, do we speak not so much of a tissue as of a mass of fluid of varying quantity and quality, holding certain corpuscular elements in suspension, and presenting merely a certain average composition in virtue of the united action of all the tissues? Unlike all other structures to which we give the name of "tissue," it appears to possess no single characteristic property, its composition being determined solely by the quantity and quality of the material poured into it by the various tissues. Hence it is considered "far more profitable, indeed necessary, to treat of the blood, not as a tissue by itself but as the great means of communication of material between the tissues properly so called" (Foster). It is usual to regard it as a mass of material by which the tissues are bathed. Hence the title frequently given to it of "the nutritive fluid of the tissues."

To regard the blood in this light seems reasonable enough in health, where we have to do with a certain average activity of all the organs of the body. Even as a working hypothesis—and it is as such that this view chiefly recommends itself—this view completely breaks down in the presence of the far more difficult problems presented by the blood in disease. So far from the blood being a mixture of water, proteids, carbohydrates, fats, etc.—from being "the nutritive fluid of the tissues,"—a consideration of all the evidence afforded by a study of its behaviour in health and disease points irresistibly to the conclusion that it is no more the "nutritive fluid" than it is the "respiratory fluid" of the tissues. In both cases alike the material, whether gaseous or solid, contained in the blood and used up by the tissues is in the blood simply in virtue of its carrying function—is in the blood simply in course of transit to the tissues.

The most remarkable feature presented by the blood is not, as is usually supposed, its varying composition, but the remarkable power it possesses of maintaining a composition as rightly entitled to be termed stable as that of any other tissue of the body, and that notwithstanding that its close relation to all the other tissues renders it peculiarly subject to such changes.

The evidence pointing to this conclusion is of a twofold kind: (1) that derived from a study of the behaviour of the blood both in health and disease, under conditions tending to alter its composition both in quantity and quality; (2) that derived from a study of the nature and composition of the plasma.

The former evidence—functional evidence—shows that the blood possesses one of the most characteristic properties of living tissues, namely, great irritability; evidenced in its case by its intolerance of the presence of bodies, even those normally present in it, such as water, sugar, peptones, salts, that do not reach it by the ordinary channels, or that reach it in too great quantity, even by the ordinary channels.

The latter evidence—structural evidence—goes to show that not only in the corpuscles, but also in the plasma, we have to do with proteid material built up into organised form, and differing from the proteid material introduced into the blood from the food.

The key to the solution of the problems presented by the blood, both in health and disease, is to be found in the recognition of this fact, that what are termed changes in its composition are in the great majority of instances merely changes in virtue of its function as the carrying tissue of the body. A clear distinction is to be drawn between changes in the blood as a tissue—structural changes—and changes in virtue of function—functional changes. The latter, however marked—sugar in diabetes, uric acid in gout—do not constitute disease of the blood; the former, however slight—deficiency in hæmoglobin, in the number of corpuscles,

etc.—do constitute disease, and their cause must always be sought, not in the tissues as a whole, but in certain organs specially concerned in the fate of the blood, the so-called blood-organs.

The conclusions arrived at from a study of the behaviour of the blood in health and disease were the following:

1. That the blood is in all respects a living tissue of highly specialised structure, adapted for the performance of certain specialised functions—namely, the conveyance of food material, gaseous and solid, to all the tissues of the body.

2. That it possesses, in common with all tissues, the power which is the characteristic feature of living tissue—the power, namely, of maintaining a certain physical structure and a certain chemical composition in the presence of the most varying physical conditions.

3. That the peculiar fluid nature of its matrix necessitates in its case special arrangements for the regulation of its composition not required by the other tissues.

4. That this mechanism is to be found partly in itself—its white corpuscles and the endothelium of its capillary walls—partly in certain organs in specially close relation to the blood, which are so situated that its composition even as a carrying tissue is regulated at certain convenient points in the circulation—namely, gastro-intestinal mucous membrane, more especially the follicular tissue around the portal radicles, the spleen, liver, bone-marrow, and lymphatic glands. With the exception of the latter, all these blood-organs possess in varying degree certain features more or less common to them all—namely, (1) slowness of circulation—common to all; (2) closeness of relation of cells to the blood—spleen and bone-marrow; (3) power of accommodating large and varying quantities of blood, chiefly venous, which the portal system, including the spleen, possesses in special degree.

PHYSIOLOGY OF TRANSFUSION.

Nutritive Properties of Blood.—In transfusing blood we are thus transfusing a living tissue presumably capable of carrying on all the functions of healthy blood. It is necessary now to consider more particularly what these are; and, first of all with regard to the nutritive properties so generally ascribed to the blood.

In Health.—Any nutritive value the blood may have must depend on the presence of its proteid constituents. Of these the blood contains about 20 per cent., distributed unequally between the corpuscles and the plasma, rather more than 15 per cent. being contained in the corpuscles, rather less than 5 per cent. in the plasma.

How is the blood affected in starvation? As the so-called “nutritive fluid of the tissues,” does it suffer in any special degree at a time when the waste of the tissues is not being replaced by food material from without? We know that, under such circumstances, the loss of substance does not affect all tissues equally. Some, as the heart muscle and the brain, suffer but little; others, as the muscles, generally lose much. Does the blood become poor in albuminous constituents out of all proportion to the loss in the other tissues, as might be expected if its substance is in the first instance used up as food? On the contrary, the observations of Voit, Panum, and Heidenhain show that the loss in weight of the blood is proportional to the general loss in weight of the tissues generally, and that the proportion of its various constituents remains unaltered. In starvation, as in health, the blood suffers quantitatively and qualitatively as other tissues. It behaves, not as a mass of nutritive material, but as a tissue. Its carrying function, nutritive and respiratory, remains the same to the last. The fact that some tissues, such as skeletal muscle, suffer much, while others, such as the heart muscle, functionally active to the very last, lose but little in weight, implies that the latter must have been nourished at the expense of the former; that food material must have been conveyed by the blood from the muscles to the heart. The nutritive function which the blood thus subserves in virtue of its carrying function remains the same as in health. The same holds true of its respiratory function. Lastly, the quantity of blood never falls below the point at which the circulation is unable to be maintained; so that the great function of circulation which the blood is enabled to discharge in virtue of its physical properties—volume, viscosity, etc.—remains unaffected.

After Transfusion.—Since the blood has no nutritive value in itself in health, apart from the material it carries, we should hardly expect it to have any after transfusion. Nevertheless, it is one of the many properties claimed for transfused blood that, even if it be destroyed, it may subserve some purpose of nutrition in the organism.

Any nutritive value the blood may have must depend on the presence of its proteid constituents. Now, the one fact definitely established with regard to the fate of proteids introduced as food by the ordinary channels is that their utilisation as food by the tissues implies their breaking up in the first place, and the excretion from the body of a quantity of nitrogen, chiefly in the form of urea, closely corresponding to the amount contained in the food. No such process is known in the body as a building up without a breaking down. Anabolism and catabolism always go hand in hand.

If to an animal in a state of starvation—whose excretion of nitrogen is entirely at the expense of its own tissues, and after a time remains fairly constant—we give a certain amount of proteid material as food, we might expect that the greater part of the material thus given would be built up into the tissues and but little be excreted. What we do find, however—as will be seen by reference to the accompanying charts, in which I have represented graphically the results obtained by Forster in his experiments—is that the whole of the nitrogen thus introduced is excreted from the body at once; there is an increased excretion of nitrogen corresponding to the quantity given in the food.

If to an animal in a similar condition a certain quantity of blood be given by the mouth, we have a similar result; the increased excretion of nitrogen corresponds to the quantity of nitrogen in the blood administered. Thus, Tchiriew found that, in a period of three days, during which 13.19 grammes of nitrogen were given in the form of blood by the mouth, the excretion was 14.55 grammes; in another period of three days, the excretion was 14.43 grammes as compared with 14.38 grammes in the food; in a third period, the excretion was 15.42 grammes as compared with 15.28 in the food.

The proteid material, whether in the form of meat or in the form of blood, had undergone disintegration; its nutritive value corresponded to the quantity of nitrogen it contained, and was expressed by the excretion of nitrogen after its administration.

Very different is the result after transfusion, when the blood is introduced directly into the vessels instead of by the mouth. As will be seen (Figs. 1 and 2), there is little or no increase in the

Fig. 1. x=394 grm. Blood transfused (15.06 grm. Nitrogen).
+ = 375 grm. Meat by the Mouth (12.75 grm. Nitrogen).

nitrogen excreted. Some slight increase there always is, but it in no way corresponds to the quantity of nitrogen contained in the injected blood. Thus, of 19.09 grammes of nitrogen in the blood transfused, only 6.85, and of 18.53 thus given only 10.60, of 7.84 only 4.39 grammes appeared in the urine in the periods over which the transfusions were made.

We must conclude, then, that blood transfused is not immediately destroyed, and its nutritive value is therefore correspond-

ingly less than the same quantity of blood given by the mouth. The two functions frequently ascribed to it at one and the same time—namely, that of discharging the functions of a living tissue and that of serving as nutritive material for the tissues—are incompatible with each other. Life of the blood implies absence of nutritive value.

Grms. Urea.

Fig. 2. x=611 gm. Blood transfused (19.92 gm. Nitrogen).
→=600 gm. Meat by the Mouth.

Under the conditions in which such experiments can best be made—namely, in starvation—the metabolism of the body is at its lowest. We shall see when we come to study the fate of the corpuscles after transfusion that starvation is particularly favourable to a lengthened stay of the red corpuscles in the circulation of their host. Hence it may be urged, and with some justice, that the more rapid destruction of blood when transfused under conditions more closely approximating those of health than the state of starvation, is, or may imply, a greater nutritive value of the blood under such circumstances than that above indicated. This is doubtless true; but in no case can the nutritive value be greater than that of a similar quantity given by the mouth, and in the small quantities transfusible in man this is so small compared with that of the food required daily by the tissues, that it may be entirely overlooked. To transfuse blood on account of any nutritive properties it may be supposed to possess is an operation entirely devoid of any physiological basis. Hence we find that the loss of weight in starvation is unaffected by transfusion of blood in whatever quantities and however often repeated; and this is the case even although at death the blood may be not only increased in quantity, but actually richer in quality, than in health. Thus in one of Tchiriew's experiments in which transfusion had been repeatedly made, and in which the weight had fallen steadily from 6.928 to 4.583 kilos., the quantity of blood obtained from the body amounted to about 8.7 per cent. of the body weight as compared with the 7 per cent. usually obtainable in health; and this blood contained 27.11 per cent. of solids with 4.21 grammes of nitrogen as compared with the 21 per cent. of solids containing about 3.2 grammes of nitrogen, usually found in healthy blood. Similar results were gained by Panum—by a method, however, not so free from objection as that of Tchiriew, on whose results, as on those of Forster, the greatest reliance can be placed.

What we have found to apply to pure blood applies in great degree to *defibrinated blood*. Its nutritive value is greater when given by the mouth than when transfused; this being due to the same cause, namely, that its red corpuscles—and they contain three-fourths of its organic constituents—continue to live for a certain time within the blood of their host. The slight rise in the excretion of urea following on the injection of defibrinated

blood is probably due to the disintegration of the proteids of the serum. This rise is never great, since the serum only contains a small percentage of organic constituents. In virtue of the change in the character of the proteids from the organised form in which they are present in the plasma to the unorganised form in which they are to be found in the serum, defibrinated blood may be regarded as possessing more immediate nutritive value for the tissues than pure blood; but this is so small that it may be neglected altogether.

Defibrination is often spoken of as harmless towards the blood; defibrinated blood is often regarded as blood minus its fibrin. Defibrination is indeed harmless towards a great number of the red corpuscles, simply on account of their firmer periplastic structure. But it kills the plasma of the blood as certainly as the removal of myosin from muscle would be equivalent to its death.

Grms. Urea.

Fig. 3. x=430 cc. Blood Serum transfused (6.88 gm. Nitrogen).
→=200 gm. Meat by the Mouth.

Grms. Urea.

Fig. 4. x=662 gm. Serum transfused (6.38 gm. Nitrogen).
→=600 gm. Meat by the Mouth.

The nutritive value of *blood serum* is the same whether given by the mouth or by injection into the blood-vessels (Figs. 3, 4, 5, and 6); but this is so small that the chief value of serum for

Grms. Urea.

Fig. 5. x=950 cc. Serum transfused (15.08 gm. Nitrogen).
→=500 gm. Meat by the Mouth.

Grms. Urea

Fig. 6. x=522 gm. Serum transfused (30 gm. albumen).
→=150 gm. Meat by the Mouth (32 gm. albumen).

transfusion purposes must depend upon its physical properties; and these are in no respect greater than those belonging to a corresponding quantity of neutral saline solution, such as $\frac{3}{4}$ per cent. sodium chloride solution.

Transfusion of pure blood is the transplantation of a living tissue made up of cellular elements floating in a fluid matrix. Transfusion of defibrinated blood is the transplantation of certain cellular elements, the red corpuscles, and also some white cor-

puscles, floating in a medium, the serum, which is not living. We might describe it therefore as the implantation of certain elements of a tissue into the living matrix of another tissue of the same kind, the plasma of the host's blood; the implantation being rendered possible by the resistant character of the red corpuscles and the fluid nature of their matrix. In either case the transfused blood has a respiratory value so long as the red corpuscles remain within the circulation of their host, and this is the only respect in which it differs from or offers any immediate advantages over a corresponding volume of a neutral saline solution, since the small percentage of organic solids it contains apart from its red corpuscles serves but little nutritive purpose, and disappears in the course of a few hours.

ABSTRACT OF THREE LECTURES ON TUBERCULOSIS IN SOME OF ITS SURGICAL ASPECTS.

Delivered at the Royal College of Surgeons of England.

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LECTURE II.

At the end of the last lecture I was about to discuss the value of excision as a method of treating tubercular joint disease.

The principle upon which the operation rests is easily grasped. It is the cutting away of a part instead of the cure of the disease in which the part has become involved. It is like removing the eyeball or the testis instead of curing the disease by which these organs may have been attacked. However favourably or safely repair may be accomplished, the fact remains that the patient has suffered a serious mutilation in the loss, in the case of a large joint, of one of the most important organs in the body.

Of course this principle may be perfectly sound, and the treatment the best that can be adopted. But this much may be said, that it is not the principle which has guided recent progress in other fields of surgery, where every effort has been made to preserve the natural structures, and to turn to the best account any which, although impaired, are not irretrievably diseased. At all events, it is a method which should be reserved for cases in which it is believed that no means of less severity will suffice.

It may be useful to recall the circumstances under which the operation of excision was introduced, now about forty years ago, by Sir William Fergusson and his school. At that date comparatively little attention had been paid to diseases of the joints, which frequently grew worse and worse, until amputation was all that remained. Under these conditions it undoubtedly was, as it was held at the time, a great advance in conservative surgery, when Fergusson and his contemporaries resorted to excision as a substitute for amputation; but although excision has had the important effect of largely diminishing the number of amputations for joint disease, it rests upon a principle which many confidently anticipate is only a link in the chain of progress.

As to the grounds on which excision is recommended, Mr. Croft thus defines the cases in which excision of the hip-joint should be performed.¹

1. When there is fluid in the joint, antiseptic incision should be made, as if the surgeon intended to excise, and he should only desist on finding the articular structures in a condition from which they could rapidly recover, and yield a movable joint.

2. When pus is known to be present, even if the surgeon is uncertain as to the condition of the joint, he should excise.

3. If the surgeon is certain that necrosis has occurred he should decidedly excise.

Mr. Barker, in his lectures here, last year, remarks: "It is most important to draw the clearest distinction between the liquefaction of caseation and true suppuration, not only as an abstract pathological axiom, but also for practical purposes. If a surgeon adopts the view that no operation is proper until suppuration has taken place in the tissues of a joint, he will always operate in

¹ *Transactions of the Clinical Society*, vol. xiii.