ZUR LEHRE VON DER TRANSFUSION

By: O. HEYFELDER.

A TRANSLATION BY PHIL LEAROYD

A copy of this paper 'On the doctrine of transfusion' by Dr. Oscar Heyfelder (1828-1890), published in the journal *Deutsche Zeitsch für Chirurgie* in 1874 (reference Vol. 4, No. 21, pages 369-381) can be read or downloaded from the following site:

https://books.google.co.uk/books?id=QSIwAAAAIAAJ&printsec=frontcover&source=gbs_atb&redir_esc=y#v=onepage&q&f=false

This paper contains an honest unbiased evaluation by the author of Dr. J. Roussel's 'Transfuseur Hermetique' apparatus for performing a blood transfusion, which includes a number of (previously unpublished) practical aspects regarding how to use it.

Heyfelder states that some of the pre-existing concerns and prejudices regarding blood transfusion in general have been refuted and overcome by actual practice and he provides an unbiased view regarding this, including the clinical indications for transfusion, which he identifies to be anaemia following blood loss, but also goes on to describe the transfusion of non-anaemic patients! In trying to give a balanced point of view, the author highlights the differences between the two types of whole blood transfusion used so far, i.e. animal arterial and human venous, and states that there is essentially no practical difference between the use of one or the other, especially when using Roussel's device, which regulates the flow of animal arterial blood that is identified to be one of its major drawbacks.

The author continues by stating that the different physiological effects of the types of blood (animal or human), the effects of the different transfusion speeds as well as the actual indications for its use and established transfusion methods are all still essentially unknown.

Heyfelder describes the practical use of Roussel's device in some detail, including the preparation of the apparatus before it can be used, the choice and preparation of the donor's and recipient's veins, insertion of the cannula, as well as the actual use of the 'Transfuseur' and the amount of blood actually transfused – information obtained from observing 26 transfusion cases.

NOTE: This paper is actually in two parts – the second part concentrates on the presentation of the medical histories of patients (both Heyfelder's and Roussel's) who have been transfused – reference: *Deutsche Zeitsch für Chirurgie*, 4, 32, 496-507, which I have not translated, but can be read or downloaded from the following site:

https://books.google.co.uk/books?id=QSIwAAAAIAAJ&printsec=frontcover&source=gbs_atb&redir_esc=y#v=onepage&q&f=false

I have produced a translation of this paper from German into English to enable its content to be appreciated by a wider audience. Whilst I am aware that instantaneous computer generated translation is available, this process struggles with accurately reading the original text and interpreting specialist terminology, as well as producing a 'colloquial style' not always representative of the original text. In addition, an 'automatic translation' may either purposely or inadvertently alter the wording to 'make it read better' but in doing so there has to be an element of interpretation involving something on the lines of 'I believe that this is what the author is actually trying to say'. I want to avoid that as much as possible and try to present what the author actually wrote and as a result the reader may find that the English

text does not ‘flow’ as well as it could. Although I have taken great care in accurately identifying the original text and producing a true representative translation of the author’s original wording I cannot guarantee that this work does not contain ‘translational errors’ and the reader is recommended to check specific details against the original text.

The paragraph settings and general layout of each part of this paper have been maintained within the translation. The references in the original text are identified by asterisks and placed at the bottom of the relevant pages. I have sequentially numbered these and placed them at the end of the translated text, reproduced as originally printed – though I have also provided translations of these (in square brackets).

ON THE DOCTRINE OF TRANSFUSION

By: Dr. O. HEYFELDER.

Through the appointment of Dr. Roussel of St. Petersburg to demonstrate his transfusion apparatus, which won a prize at the Vienna Exposition, we had the opportunity to make a number of comparative experiences in this area, which, although by no means can be viewed as conclusive, are certainly suitable for promoting and clarifying the theory of blood transfusion.

After I had previously carried out animal blood transfusions here with other colleagues, had travelled to Hasse in Nordhausen in order to attend a lamb blood transfusion there and to see healed transfused patients, and finally after I had spoken out in favour of transfusions for war injured people in my Vademecum (1): so I was given the honourable and interesting task of teaching, observing and lecturing on Roussel's transfusions in the local hospitals.

However, I was not content with the role of speaker, but in most cases took on the preparation of the vein of the blood recipient and the insertion of the cannula into it, as well as, exceptionally, the manipulation of the apparatus. It was here that Dr. Roussel provided more material for the practice of his method on a wider scale than ever before, making it possible by helping him in the various military and civil hospitals, in the hospital of the city prison and in private practice for him to carry out a number of cases (about 25). At the same time, however, we other doctors had the opportunity to study the question and to carry out transfusions ourselves with lamb's blood and human blood. - The medical-surgical academy, the general practitioners, the medical authorities dealt with the question in detail, and even the lawyers took part in it and tried to form an opinion on it by looking at it.

The lasting advantage for science is that the transfusion question has come into flux and that a number of pre-existing concerns and prejudices have been refuted and overcome by practice. Further, by encouraging Roussel, who had previously only used venous human blood, was prompted to use his apparatus to transfer lamb's blood, both venous and arterial, he himself and science were enriched by a new experience. By drawing his attention to the difficulty of inserting the blood-squirting cannula into the blood-supplying venous opening and asking him for help, I persuaded him to improve his apparatus, which he invented and implemented overnight thanks to his special talent for technology: the bifurcation of the cannula end. Furthermore, because we had to operate on less than suitable cases in those presented to us, whilst on the other hand, often had to reject cases from private practice on the grounds of unsuitability, we have also made progress in understanding the indications for transfusion.

If I now undertook to draw a picture of the current status of this scientifically and practically equally important question, as it first developed in our country under these circumstances, I would only like this attempt to be viewed as a preliminary presentation by the respected special colleges.

The transfusion can only involve whole blood. The previous series of experiments or observations relate to arterial animal blood on the one hand, and venous human blood on the other; a single transfusion has been made with venous animal blood (2) (by Roussel and myself), and no transfusion has yet been made with arterial human blood (3). The very striking differences between the two types of transfusion, which were carried out at the same time primarily with different devices, account for the differences between venous and arterial, human and animal blood, and in no way allow us to decide in favour of human or animal blood, as the champions of the two methods were inclined to do, nor do they prove absolutely for or against venous or arterial blood. To this must be added the great difference in the speed at which the blood is transferred, depending on whether it is driven into the veins by the energetic heartbeat of a larger animal or by the gentle compressions of Roussel's pump. So in one series of experiments therefore we have arterial animal blood at least three times the velocity of the opposing venous blood, human blood and the regulated slowness of the blood flow in the other.

So it can be said that we have made significant progress in terms of transfusion technology; otherwise we are still in the early stages of the doctrine.

Because we do not know the physiological effects of the different types of blood and the different speeds of the current, nor do we know the indications for blood transfusion in general, nor those for the different types of blood or established the methods.

And it is precisely with this that the study of them must begin, that we become aware of the unclear points. There would be nothing more to be regretted than if the sanguine physicians in medicine, by abusing and unprincipled use of transfusion, as well as by raising excessive hopes of it, were to bring this important and effective procedure into disrepute.

Roussel's method is essentially based on his apparatus. This is the only one that enables transfusion from vein to vein by placing the propulsion, which is practiced ‘a tergo’ in arterial transfusion through the heart of the blood donor, in the middle of the apparatus. In general, the circulatory system served as a model for his ingenious device, because the elastic pump, an extension in the middle of his tube system, corresponds to the heart, its compression imitates the systole and diastole of the heart, and the leather valves attached to the transition points prevent the blood from backing up, like those in the veins. As is well known, the apparatus (4) consists of two tube systems made of pure rubber. One begins with a cupping head made of hard rubber, has the spindle-shaped extension (pump) in the middle and ends with a double cannula made of hard rubber (bifurcation). - The elastic duct of a rubber balloon opens into the cupping head, by means of which the cupping head pressed onto the skin is pumped empty of air and sucked onto the skin. After this has been done, a suction pump with a tap, emanating from the cupping head, is lowered into warm water alkalized with sodium bicarbonate, sucks warm water into the apparatus while the spindle-shaped pump is set in motion. As water is sucked in, air is displaced. The fact that the apparatus is completely free of air is controlled partly by the surgeon's hand on the pump, partly by the attempt to empty its end cannula under water. As long as air bubbles continue to rise, as long as a gurgling noise can still be felt in the hand, the air has not been completely emptied. Only when there is certainty about this can one proceed to the operation.

This is the preparation of the apparatus, by which it is warmed up, freed of air inside, filled with warm water and suctioned over the blood donor's vein. - A second preparatory act consists in the preparation of the vein of the blood recipient. The area of skin to be incised is first anesthetized using Richardson's apparatus. Roussel originally wanted to pierce the vein subcutaneously, as Behier also does, and then expose it over as small a distance as possible and only at its upper circumference. He has come back from both ideas. Without exposing the vein by such an extensive incision as Hasse and Gesellius, since it should not be lifted out and placed under a sling, I exposed the skin over the vein by a single incision, a few centimetres long, made through a fold of skin, freed from the subcutaneous fatty cell tissue, if any, and especially the vascular sheath, carefully prepared. The latter is recommended to avoid a very annoying error. It can happen that the cannula is inserted into the vascular sheath instead of into the lumen. Only in the case of very thin, delicate veins (in

children and women) have I found it expedient to open them up with an arterial hook and thus support the insertion of the cannula. Usually we use the basilic vein, or the median, sometimes above, sometimes underneath, sometimes in the crook of the elbow, sometimes the saphenous vein. In one case I was forced to abandon the basilic under the crook of the arm as being too thin and to make a second incision on the median above the plica cubiti.

The variations in the calibre of one and the same vein depending on gender, age, individuality or in the number and course of the entire venous flow area of an extremity are innumerable. Instead of a strong basilica, there are sometimes 5-6 faint parallel branches; the divisions are sometimes much higher and sometimes much lower than they actually should be according to the textbooks. One does not like to choose a place behind which an anastomosis immediately opens or which is followed by a strong bend. - In addition to the required thickness (lumens), simplicity and straightness of the next course (at least 3-4 cm wide) is desired. If we inserted the cannula into the vein in the arm above the crook of the elbow, or found a straight course of the vessel, the wave of blood pressed out of the device met no resistance and could be traced with the eye to the armpit. Narrowness of the veins, bends, and anastomoses increased the resistance, which can be clearly felt at the pump, and sometimes caused regurgitation of the blood. - The same thing happens if the cannula is pushed too deep into the vein, so that it hits a wall in a bend. To ensure that the cannula lies securely in the vein, it must not be inserted too shallowly. Once inserted, the wound is pressed onto the cannula using the index finger, avoiding excess pressure. - The safest way to open the vein is with very fine scissors curved towards the surface, while the upper wall of the vein is fixed with a hook (Roussel), for which I preferred to use a pair of slider tweezers with fine branches or hooked tweezers. Each operator will modify this act as he sees fit and will probably change and perfect the instruments used as necessary. Roussel's cutting and piercing tweezers, similar to Chassaignac's springing and cutting tweezers for opening the trachea, were not suitable for my hand.

The constriction of the vein by the bloodletting bandage should not be loosened until the upper vein wall has been secured with the tweezers. However, if the aim is to save blood, the incision must not be made until the constricting bandage has been removed. Furthermore, the constriction must not last longer than 3-4 minutes otherwise it will inhibit the arterial inflow and gradually cause the vein to become empty. During stays in the operation, the bandage is temporarily removed and only put back on immediately before use.

A preliminary detailed examination of the vein, its course, calibre and ability to swell must be carried out beforehand. If the arm does not offer appropriate veins, the saphenous vein should be chosen. - As obvious as these precautions seem, I have seen how a not inexperienced surgeon neglected them to the detriment of himself and the patient. The examination and selection of the blood donor's vein must also be done beforehand, and it is highly advisable that these two acts be carried out separately from the actual preparations for the operation and in peace and quiet.

Since in Roussel's method, a blood recipient, a blood donor and at least one surgeon and an assistant have to be accommodated, it is by no means insignificant to try out beforehand the position of the patient on a bed or in an armchair, and that of the blood donor on a slightly lower seat, to place the two arms on a resistant surface in a natural position and relatively proximity, and to measure the relationship of the whole group to the light, so that the operators and assistants do not rob each other of the light at the decisive moment. The best way to operate is with a skylight. However, due to the length and elasticity of Roussel's transfusor, the positioning of the blood donor and the blood receiver is by no means as limited as, for example, when using Hasse's apparatus.

When the preparations have been completed on both sides in such a way that the patient’s vein is exposed, and the transfusor is attached to the blood donor’s vein, the vein is opened in the manner indicated, then the vein of the healthy person is pierced under water by a blow or pressure on the spring-loaded lancet, and the pump is set in motion. It pushes the water out of the end cannula, which first turns a little, then more red and is finally completely replaced by blood, and now we have the certainty that we have opened the vein

and are receiving blood from it. If the pump slowly fills with blood, the vein opening is insufficient and can be expanded by pushing down harder and the knife can be extended. This is what happened in 3 cases. One variant must be mentioned here. When the device ends in a bifurcation, one end cannula can be inserted into the vein of the patient then closed to the bifurcation by a valve, after which the vein of the healthy person is pierced. The blood flows out to the other cannula of the bifurcation, making one sure that the vein is pierced and delivering blood. Then the second cannula is closed using the valve, whereby the first becomes permeable, and together with the few drops of water it contains, the blood stream is transferred into the vein.

If it is difficult for the blood to flow out of the transfusor into the vein, this immediately indicates the resistance of the pump. You don't use any force to overcome this obstacle and therefore hold the pump lightly between your thumb and the four fingers of your left hand from the outset. You pull the cannula back a little, push it forward a little, reduce the pressure of the finger lying on it, remove any clothing that may be pressuring and, if necessary, remove the cannula completely so that you can reinsert it again. In addition to the feeling of the transfusor, the face is also a controller of the proper penetration of the blood into the vein. We can see with our eyes and feel with our fingertip how a rhythmic swelling of the vein, sometimes up to the armpit, follows each emptying of the pump.

Furthermore, the patient's subjective sensation is a sign of the normal course of the operation. He feels warmth along his arm, in his armpit, in his left breast; then an invigorating effect throughout the whole body, which brings with it a pleasant feeling with the adequate human venous blood and its slow introduction. A young prisoner actually expressed this feeling of well-being, and the same feeling of well-being caused a child to fall asleep during the transfusion.

In terms of disruptions in the operation with the complicated Roussel apparatus, one assumes a priori that the cupping head can come off the blood-donating arm as easily and often as possible. This is not the case. This happened once out of 25 cases, and that was due to a rough blow from outside. The blood donors did not always keep their arm absolutely still without causing the cupping head to be released.

Of the 26 cases I have observed or carried out, or of the 33 transfusions that I have become aware of and have been performed here, there have been only two haemorrhages and that was after the operation had been completed. This happened once to the tubercular prisoner who was operated on by Roussel and me in the presence of the Minister of War. The transfusion had been exemplary. During the night, while he was sleeping, the patient, without himself or those around him noticing it, suffered a considerable loss of blood from the vein (about 1 pound), which of course paralyzed the outcome. The second time it happened that the tubercular lady who I had operated on with a direct lamb's blood transfusion using a simple apparatus, a ¼ hour after the operation, which was also carried out without any propriety, at the moment of the strongest reaction lost a little blood (perhaps 1 to 1½ ʒ)from the venous wound. The bandage, which consisted only of a bandage, had to be removed and the bleeding stopped by Penghawer Djambi. Contrary to my intention, no sutures were applied due to the urgent request of the patient. This slight loss of blood had no bad consequences on the convalescence, but apparently had a calming influence on the tumultuous heart movements and the accelerated circulation; there was no blood or protein in her urine.

The period when this bleeding is to be expected from the peripheral part of the wounded vein is that of the accelerated, stormy circulation after the transfusion, either immediately or in the heat stage after the chills. If insignificant, they serve to compensate for the excess, similar to perspiration, increased urine secretion, or secretion of blood or protein with the urine; if significant the bleeding diminishes or completely cancels out the curative effect of the transfusion. They are usually undesirable and should therefore be avoided. In the event of a frightening increase in shortness of breath, cyanosis, back pain, and head congestion, we have an obvious remedy in the form of a small bloodletting from the venous wound, which we can promote or cause.

Although, therefore, we usually have to avoid secondary bleeding, especially in cases where it is a question of preserving every dram of blood, I am opposed to the application of a ligature on the basis of my experience. Although in many cases this is done without prejudice to a speedy and favourable cure, the sutures hinder the primary union and sometimes cause phlebitis, as in the two cases operated by Roussel at Kronstadt, the only one in which he made use of ligature. I consider it expedient (and have done so in recent cases) to unite the external wound by means of Carlsbad needles, thereby exerting sufficient pressure on the venous wound and, if possible, achieving primary union. The fact that some bindings exert sufficient pressure without a ligature and without a suture to prevent secondary bleeding is refuted by the two examples above. The blood donor's wound, even though it is only the same size as a phlebotomy wound, requires careful dressing and prior haemostasis. In the case of a healthy, strong farmer's wife, where Roussel had to strike two or three times to obtain blood, the bleeding was stopped only with difficulty after the transfusion was completed.

Although the surgical intervention appears to be minor for both individuals, the donor and the recipient of the blood, caution requires that both be placed under medical supervision for at least 24 hours and kept as calm as possible, in the interest of the operation as much as in that of patients.

The quantity of blood transferred is measured by Roussel's apparatus at 10 grams = ⅓ ounce for each emptying of the pump. The pump is drained six to eight times per minute, i.e. 60-80 grams of blood transferred per minute; since 60-80 heartbeats per minute can now be calculated as an average, there would be 1 gram for of transfused blood handled for each heartbeat. So, a transfusion of 240 grams takes 3 minutes, one of 320 grams. = 4 minutes. With simple devices and with arterial blood, one can only calculate approximately how much blood has flowed over in such and such seconds from the blood collected in graduated vessels before and after at a precisely measured time. With the Transfuseur hermetique, the information is only accurate if you empty the pump completely every time there is no more water in the device and no more water enters it.

Otherwise, the assumption that the patient has received 10 grams of blood from each pump emptying is too large. In the case of direct, simple transfusions with arterial blood, all the assumptions hitherto made as to the quantity of the transferred blood are also too great, because the friction necessary on the walls of the vein and the obstruction represented by the presence of blood apparently slow down the flow of blood, in contrast to the blood freely escaping into a vessel at the end of the cannula. Accordingly, in all cases of immediate transfusion, the quality of the donated blood is too high.

With the Transfuseur hermetique it can be very disturbing and downright dangerous for the success of the operation if for some reason the blood flow from the venous wound dries up. We observed such cases three times. In one case, the skin and vein wounds caused by the sniper were not large enough, in a second case, the external and internal wounds had shifted due to movement of the arm, and in a third case, the blood donor was frightened by seeing someone from the crowd of spectators faint, and immediately the blood from the vein stopped flowing.

As already mentioned, in such cases the device allows removal, cleaning and reinsertion without difficulty. However, even in the case of shorter and incomplete interruption of the blood flow, there is another means of inquiry, which was actually employed by Roussel in the last of the three cases cited. The valve on the water pipe is opened and warm alkaline water is allowed to flow in from the vessel underneath.

In this way, the blood in the apparatus is protected from stagnation and coagulation, but no harm is caused to the patient. This experience led to a further modification of the procedure. In one case of a cholera patient, blood and water were infused in approximately equal proportions without harm to the patient, but certainly without any lasting help. The symptoms during and after this operation are no different from those of a venous blood transfusion.

Roussel's apparatus made it possible to transfuse a venous lamb's blood into a decrepit mentally ill woman. The phenomena were exactly the same as those of transfusion with

venous human blood. Neither the breathlessness peculiar to arterial blood transfusions, nor congestion to the brain, lungs, heart, and other internal organs, nor pain in the kidney region, nor urine of blood, nor albuminuria occurred, nor did that severe chills and violent attack of fever follow. All secondary phenomena proceeded within the boundaries, as in the case of venous human blood. The first case is an isolated observation, but seems to indicate that it is not the animal's blood, but the blood of the arteries, directed into the vein and the right heart, that produces those perturbatory phenomena which we have previously observed in the immediate transfusion of lamb's blood, increased by the too rapid intake. However, we can attach greater importance to this observation, albeit an isolated one, because it agrees with the physiological laws and with other pathological experiences according to which arterial blood is brought into venous circulation (e.g. abnormal communication of both halves of the heart due to the opening to the foramen ovale), and increased rush of blood to the heart, whose stormy and irregular action, the capillary overfilling, also causes headaches and kidney pain. A series of comprehensive experiments would be highly recommended.

As far as the quantity of blood to be transferred is concerned, it varies depending on the patient's age, gender, anaemia and ability to excite. 2, 4, 6-8 ounces may be transfused. The slower the transfer occurs, the greater the quantity that can be tolerated. Incidentally, the right measure lies in the patient's subjective ability to endure. It is not rational to wait for the strongest signs of perturbation. In old people, the possibility of blood leakage into the brain, acute inflammation of this organ if there is kidney disease, and rupture in the case of an atheromatous process are to be feared. By the way, Hasse also came back from it.

Giving less than two ounces of blood to an adult seems inadequate and therefore not rational. If, however, even after such a small amount of blood, there are clear signs of congestion, it is necessary to slow down the blood flow as much as possible or a momentary interruption is indicated. By interruption I mean the complete removal, cleaning and subsequent re-application of the apparatus. During this pause, the introduced blood has time to distribute itself throughout the body, the arteries to dilate, and the heart to cope with the increased flow of blood. On the other hand, transfusion, is not an easy, simple, and pleasant operation to allow the same patient to undergo several small transfusions at short intervals (of days), as some authors suggest as a rule.

In order to reduce the speed of the initiated blood flow, even during arterial blood transfusion, Roussel’s pump can be transferred to any transfusor. Since the danger of a longer rubber tube is refuted by its more than 1 foot long tube, I also use a ½ - ⅓ foot long tube for the immediate transfusion with arterial animal blood and inhibit the speed of the blood flow by rhythmically squeezing the tube.

Various observations and experiments with Roussel's apparatus and with the apparatus I have modified have proved that the fear of clot formation is exaggerated. The formation of individual small clots has not been observed. When the movement of the bloodstream ceases, or the apparatus is not warm enough, the entire mass of blood in it coagulates and stands like a column of jelly in the lumen, so that no more fluid flows at all. Likewise, if the blood mass in Roussel's apparatus is allowed to cool, it will initially be evenly filled with a gelatinous blood, which gives the pump the impression of compact padding, the pressure changed or offers increased resistance, but can initially be squeezed out in its entirety by strong pressure, namely in the form of a worm-shaped, soft mass. The gelatinous thickening begins peripherally from the walls and gradually progresses towards the centre, so that even more liquid blood is preserved in it. It even seems to follow from individual observations that if the apparatus is immediately heated up again and new liquid blood flows in in time, the whole mass becomes liquid again and the action of the apparatus proceeds properly again. But if coagulation has taken place, this moderate pressure a tergo, which the heart of a young animal or the hand of the surgeon familiar with the apparatus exerts through the pump, is not sufficient to force the stagnant mass of blood through the fine cannula.

A minimum of air, which is still found in a transfusion apparatus and is driven into a vein of the upper or lower extremity, may be relatively harmless and may be absorbed by the mass of blood before it reaches the heart, though by no means irrelevant to the degree that Behier supposes. As the contact of air takes a moment to coagulate the blood, and the entry

of large quantities of air into the heart has a fatal effect, the ability to exclude of air in Roussel's apparatus is a great advantage.

According to the current state of experience, the normal indication for transfusion is: Lack of blood due to acute blood loss to a life-threatening degree, i.e. in practice mainly after injuries (operation - accidental injury of war wounded) and after maternal bleeding (women giving birth and uterine sufferers).

Initially, anaemia due to repeated blood losses appears to be a sufficient indication: metrorrhagia, intestinal bleeding (dysentery and intestinal ulcers) and secondary bleeding of injured persons.

Experience has yet to decide to what extent anaemia and blood thinning, caused by chronic disease processes, indicate the same. In particular, Hasse's, others and my experiences seem to prove a favourable effect on pulmonary phthisis, Roussel's and my observations on a cure of scurvy by transfusion. Two cases from my series of observations speak for the healing effect on pus lesions; in particular, a psoas abscess was cured by him in the local Marienhospital.

According to the experiments of Rautenberg, Kühne and others, poisoning with poisons that directly change the blood mass, can be cured by transfusion.

A prophylactic transfusion for bloody operations in very anaemic subjects seems rational, as does a supportive transfusion in starving patients.

The transfusion acts not only as a quantitative substitute, but also qualitatively, like a chemical agent on all organs, especially on the heart and nerve centres, which gives the impetus to a more energetic function and better nutrition of all tissues. The healthy blood seems to act as an adequate stimulus on the tissues.

Animal blood, i.e., warm mammalian blood of the corresponding size of blood cells, does not seem to have any different effect from human blood.

Arterial blood has a more energetic, invigorating effect than venous blood. Therefore, where it is only a question of replacement, the venous is sufficient; where it is a question of revitalization and amelioration, the arterial is preferable, whereby in an emergency one would not shy away from arterial human blood.

In any case, venous and arterial animal blood and human blood have almost equal justification for transfusion, and very often only the easier possibility of procuring one or the other will tip the scales in favour of this or that. The whereabouts of animal blood cells in human blood, their effect on human blood cells, their changes, and the duration of their existence, must be answered by microscopic examinations, analogous to those of Landois in animals.

(1) Kriegschirurg. Vademecum von Dr. O. Heyfelder. Petersburg, 1874. Seite 215 u.f. [War surgeon. Vademecum by Dr. O. Heyfelder. Petersburg, 1874. Page 215 u.f.]
(2) Die 1839 von Bliedung mit Venenblut eines Bockes veranstaltete Transfusion ist möglicher Weise mit ganzem Blut gemacht; ich kann es aber bei der Nichtangabe der Methode in den Monographien und bei mir mangelnder Einsicht in das Original nicht entscheiden. [The transfusion carried out by Bliedung in 1839 with venous blood from a ram was possibly made with whole blood; however, I cannot decide because the method is not stated in the monographs and because I do not have access to the original.]
(3) Eine solche Transfusion von der Arterie des Menschen zur Arterie des Menschen theilte Herr Dr. Küster in Berlin auf der diesjährigen Versammlung der deutschen chirurgischen Gesellschaft mit. [Such a transfusion from the artery of man to the artery of man was announced by Dr. Küster in Berlin at this year's meeting of the German Surgical Society.]
(4) Zum ersten Mal beschrieben und abgebildet Gaz. des hôp. de Paris. 1865. Sept. [Described and depicted for the first time Gaz. des hôp. de Paris. 1865. Sept.]