BEITRÄGE ZUR BLUTTRANSFUSION

By: J. NEUDÖRFER

A TRANSLATION OF PAGE 583-600 OF PART ONE AND PAGES 47-68 OF PART TWO OF THIS PAPER BY PHIL LEAROYD

The extremely lengthy and comprehensive paper 'Contributions to blood transfusion' by J. Neudörfer was published in 1875, in two separate parts, in the journal *Deutsche Zeitschrift für Chirurgie* [references: Vol. 5, No. 20, pages 537-600 and Vol. 6, No. 2, pages 47–112], a copy of which can be viewed or downloaded from the following sites:

Part 1:
https://books.google.com.sl/books?id=TvRlAAAAcAAJ&printsec=frontcover#v=onepage&q&f=false

Part 2:
https://books.google.com.ag/books?id=FrlpAAAAcAAJ&printsec=frontcover#v=onepage&q&f=false

Neudörfer discusses a large variety of blood transfusion topics in detail within these two papers, including a lengthy description of some of his own research. Within sections of these two papers he also describes, discusses and illustrates different devices that have been used for both direct (immediate) and indirect (mediate) transfusions using both human and animal blood, i.e. within pages 583-600 of the first part, and within pages 47-68 of the second part. The illustrations of the different devices discussed by the author are included within four separate pages of plates that are printed at the end of part one of this paper.

The first section starts by giving a detailed description of how to correctly access the patient's vein using a cannula (and not a trocar) and then describes the process for defibrinating blood in some detail and comments that in his experience it does not delay or complicate the transfusion operation as he does not consider this (unsterile) procedure as taking a lot of time.

The author then describes the method for transfusing defibrinated blood, starting with using syringes of different types followed by devices for 'pressure injecting' the blood, though the description of his preferred method of use is not clearly defined (i.e. Fig. 10). He states that he has performed over 50 transfusions with defibrinated blood, usually using 4-5 ounces, and that he finds that if a syringe is used carefully, ingress of air into the patient's vein is not a problem. He stresses the need to inject the blood slowly, i.e. 15-20 grams / minute, and discusses the limitations of 'pressure' devices and from these comments describes a safer pressure device for the transfusion of defibrinated blood (i.e. Fig. 11), then somewhat strangely considers the transfusion of defibrinated blood into an artery rather than a vein – the description of which is rather difficult to understand.

He then moves onto describing methods of transfusing whole blood, considering both direct as well as indirect methodologies – the simplest method again involving using a syringe – and discusses the problem of the blood coagulating.

The second section therefore starts with Neudörfer discussing blood temperature and relating it to its coagulability – though whilst identifying that coagulation is slower at lower temperatures he states that he worries about the effects that transfusing blood at room temperature has on the patient's heart, though he does concede that a temperature of 37°C 'does not need to be rigorously maintained'. Given the discussion of coagulation times, he considers complex time consuming devices for indirect whole blood transfusions disadvantageous.

The author then goes on to consider direct transfusion in humans and the problems of knowing the amount transfused in direct vein-to-vein transfusions, as well as ensuring that the blood transfers quickly enough and comments on different devices and the effects on the blood donor. He goes on the describe Gesselius's device and how it is used, referring to a rather poor drawing of it (Fig. 12), whilst also providing his own personal comments about the device and its use.

Finally he discusses the use of animal (sheep and lamb) blood transfusion methods starting with some rather vague physiological arguments relating to their clinical effects. The direct artery to vein methodology is criticised regarding the dangers of using glass cannulas (that enable the blood to be seen) and the inability of identifying the movement of the blood and the amount of blood transfused; but this is followed by a description of a cannula designed to be left in the carotid artery of an animal and his own direct animal-to-man transfusion device for the 'urgent transfusion of battlefield casualties'.

I have translated a section of Neudörfer's paper that refers to different transfusion devices / methods from the original German into English in the hope that the content may be appreciated by a wider audience. Whilst I am obviously aware that instantaneous computer-generated translation is possible, this process struggles with specialist terminology and also produces a 'colloquial style' not always representative of the original text. I have purposely produced this translation to be 'un-interpreted', in that I wanted to maintain the author's original meaning / wording as much as possible. As with any translation the wording may be purposely or inadvertently altered to 'make it read better' but in doing so there has to be an element of personal interpretation involving something on the lines of 'I believe that this is what the author is actually trying to say'. I wanted to avoid that as much as possible and try to present what the author actually wrote and as such the reader may find that the English text does not 'flow' as well as it could. Although I have taken great care not to misrepresent 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.

I have maintained the overall layout and paragraph settings of the original paper, and reproduced the words in italics and the spellings of names (some of which are spelt incorrectly) as printed in the original paper. The references, numbered and placed at the bottom of each page of the original paper have been collected together from the two separate parts, sequentially re-numbered and placed at the end of the translation of the translation. The figures referred to in the text are also presented together at the end of the translation in a series of four 'plates' (i.e. pages), as they are in the original paper. I have however re-labelled the plate numbers so as to be more easily identifiable. Note: The right hand end of Fig. 13 shown in Plate 3 is reproduced on the left-hand side of Plate 4 (i.e. the knob *k*), and the left-hand end of Fig. 15 shown in Plate 4 is reproduced on the right-hand side of Plate 3 (i.e. the attachment piece *a*). Some of the letters related to these different figures may not be able to be easily read – their reproduction is rather poor in the original document.

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‘TRANSFUSION DEVICES AND METHODS’

PART 1 – PAGES 583-600

I think I shall facilitate the survey of the various methods, and avoid repetitions, if I first begin with a critical examination of that part of the transfusion technique which always remains the same in all transfusion methods, namely, the opening of the vein of the blood recipient, and the insertion of a suitable tube into it, which forms an orificium or funnel for the convenient introduction of the blood. Usually, a vein in the crook of the elbow is chosen. The reason for this choice lies in tradition; for centuries, when veins need to be opened, they are opened in the crook of the elbow; but there are other reasons for this location. Here you will find a confluence of several veins in a relatively narrow limited space and therefore have a relatively large selection; the veins at this point are also neither too large nor too small. This area also presents the smallest amount of inconvenience both for the operation and for the aftercare, for the doctor as well as for the patient. These advantages, in combination with tradition, explain the custom of opening the veins necessary for transfusion purposes in the crook of the elbow. One must only be clear about the fact that it is merely a custom and that with the same success one can choose a vein on the flexor side of the forearm or on the back of the hand or on the upper arm for transfusion. Although it is permissible to use one of the many cutaneous veins on the lower extremities, but this will be done only in the rare cases where the cutaneous veins of the upper extremity are not to be used for any reason, because the veins of the lower extremities are generally somewhat too large for the ordinary cannulas (which is associated with greater inconveniencies, as if the vein is too small); furthermore, because the operation and follow-up treatment is equally inconvenient for the doctor and the patient, and lastly, because the healing of all, and especially of the venous wounds on the lower extremities, proceeds more slowly and with difficulty than on the upper extremity. The superficial or cutaneous veins in the chest and abdominal area may be chosen, where they are visible. While the cutaneous veins on the upper and lower extremities have a completely constant position and leave no doubt about the direction of their course, this is not the case with the cutaneous veins of the chest and abdominal region. Only in every fifth person, for example, are cutaneous veins on the chest or abdominal region visible, and one must first orient oneself as to the direction of their course, which is easily achieved by applying local pressure on the veins, because one knows immediately that the peripheral part of the vein is full and swollen, while the central part of the vein is empty and flat. Also from the ramification of the veins, where such veins are visible on the skin, one can sometimes, but not always, infer the direction of the course of the veins. Usually the course of the veins is towards the angle at which two veins meet, and it seldom happens that the course becomes an opposite one by a dichotomous division of the veins, as in the median vein. However, a vein in the neck must never be opened for transfusion purposes, because the danger of overcrowding of the right heart and the shock is hardly less than the danger of lethal air entering the external jugular vein.

As far as the opening of the vein itself is concerned, it is striking that the majority of the authors do not open the vein with the knife or scissors, but with the trocar (E von Gräfe (1), Martin (2), Demme (3), Mancoq (4), Braune (5), Eulenburg and Landois (6), Uterhart (7) and others). If one asks about the reason for this surgically not entirely correct procedure, one must answer that all the authors mentioned are under the impression of "imminent danger", that they therefore display a haste in their surgical technique; they therefore consider it a time-saver instead of the two moments of opening the vein and inserting a cannula into the open vein, only one moment of needing the insertion of a trocar into the vein. I have often pointed out that the transfusion is by no means a matter of seconds or minutes, but that, on the contrary, in all indicated cases there is time enough to carry out the transfusion according to all the rules of surgery. The comparison with laryngotomy involuntarily comes to mind. If anywhere, there is danger in this operation, and there have also been a number of surgeons for this operation too who opened the trachea by puncture from the outside at a rapid pace. At present this method has been completely abandoned; I know of no surgeon who would perform the laryngotomy at a rapid pace in order to save time; it is also common knowledge that if breathing also stops during the operation, one can calmly complete the operation and achieve the desired surgical result by artificial breathing. It's exactly the same with transfusions. Even in the case of acute anemia, there is time to perform the operation lege artis in all its details, even if the person bleeding to death is unconscious or even seemingly dead; as long as the central nervous system has not entirely lost its irritability, there is time to make the transfusion, even if hours have elapsed since the bleeding; but when this irritability is extinguished, then there is no use in haste, it is too late. I do not wish to be misunderstood, I am by no means advocating the delay and loss of time in the transfusion, but I must also make use of the necessary muse for this operation, and I cannot admit that, in order to save a few seconds of time, a method is used which is likely to frustrate the execution of the operation and endanger the life of the person being operated on. Just imagine how easily the trocar can penetrate the posterior venous wall and how easily the lumen of the vein can be missed, and I believe that this act of surgery, the opening of the vein with the trocar, is likely to deter many surgeons from transfusion. I am against the application of the trocar for the opening of the vein and can therefore completely refrain from a criticism of the various trocars. I consider the artificial opening of the vein and the insertion of a suitable cantle into the open vein to be the only correct method, and as Billroth (8) with his weighty authority declares this act to be difficult, this act of operation may be described more precisely than was originally intended. It is often believed that it is very difficult to find veins in acute and chronic anaemia because the concept of anaemia is associated with a state of strong traction of the veins, an idea that is not entirely correct. In the first place, it must be noted that the breadth and fullness of the veins depends chiefly on the resistance to the movement of the blood, and that in acute and chronic anaemias, where the heart's strength is weakened, the veins tend to be wide and full; the histological structure of the veins is also such that when the blood drains out, the vein does not contract, but sinks together, flattens itself, and I would like to point out that in the very large number of transfusions which I have performed on anaemic patients, in only about 2 or 3 times were very narrow veins found, but otherwise veins of normal width and a few times of great width. In the case of delicately translucent skin, the veins can be seen, or at least recognized, through the skin, but if the skin is thick and coarse, pale or heavily pigmented, there is certainly no trace of the veins running under the skin to be discovered, and it is these cases that the surgeons may have had in mind when they declared the opening of the vein to be a difficult part of the transfusion. This difficulty, however, is easy to eliminate; one has only to separate the skin in the direction of the vein to see the formerly invisible vein fully and broadly in front of you. The use of the trocar is also inexpedient on the exposed vein, and it must be opened through an incision. A longitudinal incision would indeed be the most favourable for the subsequent healing of the vein, but this incision makes the insertion of the cannula extremely difficult. I have found it most expedient to raise the exposed vein at its anterior surface in a fold with eye tweezers and to make a > shaped incision with fine (eye) scissors. This flap-shaped incision will make inserting the cannula into the vein much easier. One has only to raise the lobe with Fischer's tweezers to be able to see into the lumen of the vein, and if the opening is too small, one has only to widen one or the other edge of the lobe a little. Instead of eye tweezers, you can also use a fine hook, which you hook into the vein; then the vein is lifted up in a fold-like manner and cut with the scissors. In this meticulous act, it is important to be sure that the venous wall has been completely severed, because in the case of collapsed veins it is very easy to be mistaken about this point. I used to carefully isolate the vein from its support, and place two sutures under it as if for ligation, but later omitted this manipulation as superfluous. – I only use hard rubber for the venous tube.

Fig. 1 (Plate 1) shows my venous cannula *C* in its natural size on average. One can see from the drawing the gentle curvature and the gradual thickening of the cannula towards the end of the cannula towards the end facing away from the vein. To this cannula *C*, belongs the mandrel *D*, which is able to completely fill its lumen. When the cannula is inserted into the vein, the spine is stuck in the cannula and transforms it, as it were, into a massive, unpierced rod. Such a cannula, provided with a thorn, can lie in the vein for any length of time and remain there without letting a drop of blood flow out and without causing irritation to the vein. Nor does it need to be bound into the vein, but remains there quietly until the beginning of the introduction of blood, when the spine is pulled out. The cannula then fills by itself through the receding blood, or the filling is produced by gently stroking the vein in the retrograde direction. The execution of this act of operation is briefly as follows: The patient is positioned against the edge of the bed, the arm is strongly abducted, and the surgeon stands on the outer side of the arm when surgery is performed on the right arm, on the inner side of the arm when the left. If the skin is translucent, it is raised above the vein chosen for transfusion into a fold perpendicular to the direction of the vein, and with a pointed bistouri from the base towards the free edge of the fold to the extent of 3 cm is split. If the vein is not seen or recognized through the skin, then an attempt is made to make the vein recognizable by letting the arm hang down or by a constricting bandage above, i.e., centrally from the polling site; if this does not succeed, then one has only to casually raise and cut a fold in the direction of the chosen vein, the edges then gape apart sharply, and within the gap space in the skin, which can be considerably enlarged by moving one or the other of the cleavage margins, one will certainly find the vein you are looking for. This can be grasped as it is with Fischer's tweezers or a fine hook, raised and incised with fine scissors, but the vein can also be freed from connective tissue on its upper surface, and anxious surgeons may isolate the vein in one place in its entire circumference. This much is certain, the less the vein is exposed of its protective and nourishing connective tissue, the less significant the venous injury. The cannula, which is mounted with the mandrel, is inserted into the lobe-shaped venous wound and advanced until the venous opening is closed by the thicker part of the cannula. I haven't needed a thread at all lately. A gentle touch with the finger is enough to keep the cannula in place.

The operational act described here for the opening of the vein remains the same for all methods of venous transfusion; the other acts of surgery vary according to the different transfusion methods and must therefore be discussed individually.

We begin with the transfusion with defibrinated blood, and first have to describe the act of defibrination. The preparations for this are extremely simple. All you need is warm water at a temperature of 36-37°C., a porcelain bowl, a stick of soft wood, a beaker, a funnel and an old, cleanly washed fine canvas cloth. You start by letting the blood donor sit down, and have the arm supported or hold in a suitable position. You tie the arm above the elbow joint with a bandage and open one of the swollen veins in the crook of the elbow according to the known rules. The venous blood stream is collected in a porcelain bowl standing in a water bath and immediately stirred with the wooden stick. I used to use dry broomsticks, a metal whisk or a glass stick, but lately I have cut a stick from soft fir or spruce wood, as can be found in every kitchen, measuring 30 to 40 cm. long, 2-3 cm. wide and 1 cm. thick, and used it for defibrination. With this rod, the blood in the porcelain bowl is always moved in one direction, in 3-7 minutes the wooden rod is covered with fibrous clots at its lower end. The blood from the vein is allowed to flow until 6-8 ounces have been collected; then the bloodletting wound is closed and bandaged with the finger, while the blood in the porcelain bowl is still beaten. When no more fibrin is excreted (which, of course, can only be judged approximately, but for the transfusion the casual estimate is sufficient), then the blood is strained into a beaker standing in a 36-37 degree water bath. It is best to hang a funnel in the beaker, in which the canvas is spread out as a filter. By the way, you can spread the canvas directly over the beaker and filter the blood. If you have not only turned the wooden stick, but have beaten the blood with it, then it contains a lot of foam, which delays the filtration process. If you let yourself be tempted to force the blood through the canvas sieve in order to speed up the colature, then you press many air bubbles with it, which is not recommended. The defibrination act including straining requires 15-20 minutes; during this time the blood can be defibrinated and ready for injection without trained assistance; under favourable conditions, this act can be completed in 5 minutes. It follows from this that the accusation of a great loss of time in the defibrination act is completely unfounded.

We now come to the last act, the transfer of the defibrinated blood into the vein, or into the cannula inserted into the vein. For this purpose, very different means were used, and at first the simplest instrument, which could be procured everywhere, the ordinary syringe, was used. This must be warmed, slowly filled, freed from any air bubbles after filling and then slowly emptied into the vein. It is indeed possible to carry out quite faultless transfusions in this way, but partly because of the less favourable results, and partly because of the desire to simplify the surgical technique and to be able to prevent the danger of air entering the vein, the simple syringe has been modified in many ways and completely abandoned. The first innovation was the abolition of metal and any opaque substance as syringe material. The body of the syringe was to be made of glass and only the mount, the frame, was to be made of metal or hard rubber. Such a syringe shows existing air bubbles, for example, which can then be removed with certainty.

H. Demme (9) has tried to improve the syringe by using one which is at the same time a suction and pressure pump (Fig. 2, Plate 1). The upper end of the syringe contains two cone valves that open in opposite directions; therefore, once the syringe is filled with blood, it can be emptied and refilled as often as desired without air being able to enter the syringe.

Eulenburg and Landois (10) have their syringe (Fig. 3, Plate 1) with a so-called air catcher (*L*). This is a $1^1/_4$ inch long metal drum of elliptical cross-section; the height of the ellipse is 1", the width is $^3/_4$". The syringe is attached to this air catcher hard at the top of the metal drum, and the discharge tube is at the bottom of the opposite surface of the metal drum. If, therefore, there really are air bubbles in the syringe, they remain at the highest point, while the blood flows into the vein from the lowest point of the drum, i.e. free of air.

Uterhart (11) has carried out the same idea of leading the air bubbles upwards and allowing the blood to escape at the bottom, by placing the outlet tube of a normally mounted glass syringe eccentrically against the edge of the syringe (Fig. 4, Plate 1). If the syringe is held in such a way that the outflow pipe is at the bottom, any air bubble that may be present cannot be injected with the blood because it rises upwards. Graily Hewitt achieved the same goal by using a venous cannula bent at a right angle, which means that the ordinary glass syringe must be held vertically during the operation, so the air rises to the syringe plunger and does not enter the vein.

Mosler (12) has constructed a syringe which holds 270 cc. of liquid, and carries a scale divided according to cubic centimeters. The plunger can be moved by tension and by twisting screws. You can see in Fig. 5 (Plate 1), which is drawn enlarged in the adjacent figures *A* and *B*, and can easily recognize that when the levers *h* in figures *A* and *B* are closed, the punch can only be moved by turning the screw, when they are open, they can only be moved by pulling. The advantage of this syringe is its strength, its careful construction, the possibility of transfusing very slowly, the ability to read the measure of the injected liquid very accurately, and the cannula not having to be tied into the vein.

Braune (13), who also used the syringe at first, fears that oil droplets could enter the blood from the oiled punch and produce embolisms there, so he leaves the syringe and applies the hydrostatic pressure of a 1' high blood column (Fig. 6, Plate 1).

Richardson's (14) proposal represents a significant advance in the technique of indirect transfusion. Richardson recommended that instead of the mechanical force with the syringe plunger, the pressure of compressed air should be used as a moving force. Fig. 7 (Plate 2) shows his apparatus: air is injected into a closed cylinder glass, in which the defibrinated blood is contained and which is connected to a rubber blower, such as is used for local anesthesia, which is able to set the blood in motion with a certain force. The entry of air into the vein is prevented by the fact that when the liquid level has dropped to almost the outlet opening, a rubber balloon wedges itself into the neck of the glass, which is narrowed at this point, and makes it impossible for air and blood to escape at the same time.

Belina-Swiontovski (15) applies Richardson's principle of air pressure as a driving force in such a way that it puts the defibrinated blood into an inverted bottle (Fig. 8, Plate 2); the inverted, downward-facing narrow end of the 300 cc bottle is connected by a rubber tube with a trocar, which is intended to open the vein and through whose cannula the defibrinated blood is to be conducted into the vein. The upper wide end, the former bottom of the bottle, is connected with a rubber balloon, which functions as a compression pump through its two valves. As often as the rubber balloon, which rests in the palm and is compressed by it, air is forced into the blood-free space of the bottle, and this air pressure drives a quantity of blood into the vein; a scale divided into cubic centimetres gives an precise indication of the quantity of the blood transfused.

Gesellius (16), who has much to complain about Belina's device, among other things the inconvenience of it, and chiefly its great danger when the device is tilted by the carelessness of the surgeon, where the air should then penetrate the vein with great force, has constructed a device, not for defibrinated blood, but for whole blood, which, however, may be discussed here. For the transfusion he combines the hydrostatic pressure with the air pressure through the Richardson rubber blower. Fig. 9 (Plate 2) represents his device. It is a cylindrical graduated vessel with a conical bottom, enclosed with a double coat of rubberized white silk, which is filled with water of 37°C. The jar is hermetically sealed with a lid and connected to a rubber blower. As long as the blood flows into the vein through the hydrostatic pressure, no use is made of the blower; but if the resistance in the vein grows, then it is safely overcome by the blower.

I myself have performed the operation with defibrinated human blood more than 50 times; I have done it with various syringes, with the original Richardson's apparatus, with the transfusion apparatus constructed by Leiter (17). In Fig. 10 (Plate 3), *P* represents an average pump, which acts as a suction and pressure pump, depending on whether it is placed on the bottle *F*, as in the drawing, or vice versa; *o* and *v* are the valves which, by their play, drive or draw air into the channel *k k*, by which a liquid in the bottle *F* is pressed out or sucked in through the tube *r*, carried out with a syringe bottle and with Wulf's bottle with the aid of a blower, unfortunately also made twice with the large Hering's injection apparatus instead of the rubber blower. I have usually transfused 4 to 5 ounces of blood, only exceptionally have I risen to 11 ounces. I did my transfusions with blood that was at 37 degrees, but also cooled down to 20°. In these experiments the following conviction forced itself upon me: "transfusion with defibrinated blood" is much easier for the surgeon to perform than any other; the defibrination act does not delay or complicate the operation. One can use an ordinary, well-closing pure glass syringe or even a metal syringe without any disadvantage to the patient, but one can just as well use one of the devices described here, if one is only clear about the real dangers of transfusion and does not put the tenor on imaginary dangers. Such imaginary dangers are the penetration of a single air bubble into the vein, for this is the only thing that can be involved in the transfusion if one has a well-closing device and observes the precautions that are necessary when working with the syringe for injection preparations. If I can trust my observations of animals and men, I cannot describe the entry of an air bubble into a vein of the extremities as life-threatening; on the contrary, I consider such an event to be completely harmless, but I do not mean to say that the ingress of air is permitted during the transfusion, the exact execution of the operation requires that no air bubbles enter the vein, and this can also be achieved with ease and certainty in the case of transfusion with the ordinary syringe. Even in the cooling of the transfused blood (up to 20°C) I could not perceive any danger to the patient. On the other hand, in the continuity of the transfused blood, as well as in the magnitude of the pressure and the velocity with which the defibrinated blood is driven into the right heart, there is a great danger to the recipient of the blood, either from the shock or by the lethal effect on the central nervous system, in a few hours after the operation. Both cases, in which I used Hering's injection apparatus as an engine (with the pressure setting of half an atmosphere), were fatal in consequence of the operation, i.e. of the continuous great pressure, in the first 24 hours after the operation. If you transfuse very slowly, then as a rule the stormy phenomena of the transfusion do not occur, and I would like to consider it the ideal of a transfusion if it is carried out so slowly that only 15-20 gm of blood reach the heart per minute, while the completion of the transfusion in one minute, i.e. the introduction of 150-200 gm of blood into the heart in one minute, can have very considerable dangers for the patient, and it must be expressly mentioned here that all those transfusion devices which have the task of completing the transfusion in a very short time, however ingenious their construction may be, are not to be regarded as advances in the transfusion technique, but rather are to be rejected.

Of the devices which use the pressure of compressed air as an engine, i.e. of the transfusion devices constructed by Richardson, Belina, Gesellius, and Leiter, I must assign the first rank to that constructed by Leiter, while that of Belina occupies the last place, because the latter (in addition to the weighty objections raised by Gesellius) has the great disadvantage of the being bound to the trocar, and because when using a single rubber balloon, the blood pressure is intermittent, whereas in the case of the rubber blower with two rubber balloons, as Richardson has suggested, the pressure is uniform. I cannot speak of Richardson's device either, because too much blood is lost in it, for the quantity of blood below the constriction of the glass is dead mass which must not be used, and cleaning the device is also very cumbersome and difficult to describe. In the device of Gesellius, the expensive rubberized silk coating, which serves to keep the blood warm, is quite unnecessary, because the glass is in itself a poor conductor of heat; therefore, if it is warmed before the operation, it keeps the warm blood warm enough for the duration of the transfusion; besides, it has no bad consequences at all if the blood, which has cooled down a few degrees below the temperature of the blood, is transfused. Braune's device (Fig. 6, Plate 1) is also not recommended, because, as you can see, it is not very handy, because the pressure cannot be increased with it, and because the pressure decreases with the outflow of the blood; therefore, if hydrostatic pressure is to be used as a motive force, it is better to employ an apparatus constructed on the principle of Esmarch's irrigator, i.e. a graduated glass vessel, which is connected at its lower end with a metre-long, thin rubber tube, which can be raised and lowered at will, thereby increasing or decreasing the transfusion pressure. The precaution against the ingress of air is exactly the same as in the case of the Braune tube. If one lays emphasis on a slow and completely uniform introduction of the defibrinated blood into the vein, with the exclusion of shocks, one can very easily construct or improvise a so-called automatic transfusor in the following way: a Wulf bottle or a glass flask of the shape of a spray bottle and the size of 500 cm to one litre is closed with a double-pierced rubber or dense cork stopper. Two glass tubes bent at right angles pass through the stopper, one of which ends close to the stopper, while the second reaches to the bottom of the container. This glass flask is intended to receive the defibrinated blood to be transfused. A second glass vessel of any shape and size is also closed by a double-pierced stopper, through which two glass tubes pass, one of which, bent at right angles, ends close to the stopper, while the second, straight or bent at a right angle, extends to the bottom of the glass vessel. If the two right-angled glass tubes ending near below the stopper are connected to each other by a rubber tube, and if the glass tube, which reaches straight to the bottom of the bottle, is connected to a water reservoir, preferably to an ordinary irrigator, then as soon as the squeeze tap is ventilated, the water from the irrigator will flow into the glass vessel and displace the air which overflows into the communicating flask, which is partially filled with defibrinated blood, and pushes the blood out through the second glass tube bent at right angles, which reaches to the bottom; if the free end of this glass tube is now connected to a rubber tube, which carries an attachment piece at its free end, intended for the reception or insertion of our venous tube described above (Fig. 1, Plate 1), the transfusion will proceed of itself as long as blood is present. It does not need to be discussed at length how to protect oneself against any ingress of air with this automatic transfusor; but it must be mentioned that with this device it was entirely within one's control to accelerate or delay the transfusion flow by regulating the velocity of the incoming water, by raising and lowering the water reservoir, and by arbitrarily choosing the cross-section of the vessel serving as an air chamber to delay, but the transfusion pressure always acts uniformly. Fig. 11 (Plate 3) represents such an improvised automatic transfusor; in it I represent the irrigator, *W* the air-chamber, and *F* the bottle containing the defibrinated blood.

I have dealt more extensively with the technique of transfusion with defibrinated blood, because there are still many surgeons who wish to transfuse only with defibrinated blood, because, furthermore, transfusion with defibrinated blood can lead to the desired result, although the chances of a favourable outcome of this operation are relatively small, i.e. much less than in the case of surgery with whole blood; lastly, because, as has been shown above, there are cases in which transfusion with defibrinated blood is the only permissible one.

This discussion is naturally followed by transfusion with defibrinated blood, instead of into the vein, into the artery. The technique of arterial transfusion, as Hueter calls it, or capillary transfusion, as I call it (because, strictly speaking, the radial artery, as well as the posterior tibial artery, represent only the entrance into the capillaries of the hand and foot), can be carried out with all the devices previously described, in so far as they are equipped for great compressive forces, and only the opening of the artery is associated with a slight modification. How to expose and isolate the radial or post tibial artery must be familiar to anyone who wants to carry out a transfusion. I must therefore assume that this preliminary act is known and has already happened. So I assume that the radial or post tibial artery is exposed and isolated, then a double thread is placed under it and the central end is knotted, as in a continuity ligation; under this ligature, the artery is opened laterally, the cannula described earlier (Fig. 1, Plate 1) with the cannula is inserted into the end of the artery and integrated there. Before the defibrinated blood is pressed into the cannula, the spine must be extracted from it. In the radial artery, it can and often will happen that a negative pressure occurs in the peripheral end of the artery, which allows capillary blood to escape through the cannula; the free end of the transfusion device, which also has a blood meniscus, is inserted into this free end of the cannula bound into the artery, which bearing a blood meniscus, also excludes any entry of air into the artery; but if such a negative pressure does not occur, then it is necessary to fill the cannula with liquid after pulling the mandrel out of it; it is best to use a glass tube drawn into a fine point, into which defibrinated blood is sucked up; but you can also use a two-proc. Sodium bicarbonate solution or a semi-proc. saline solution, and from this the liquid is blown into the cannula, the air is displaced by the liquid and you have a prominent liquid meniscus again at the free end of the cannula, into which the end piece of the transfusor is then inserted as before. The same procedure is followed if, instead of through the entrance to the capillaries, i.e. through the end of an artery, the transfusion is carried out through a main trunk of an artery, for example, into the brachial artery.

I am now moving onto a whole blood transfusion. While only indirect transfusion is considered when transfusing with defibrinated blood, the direct transfusion method must also be taken into account when transfusing with whole blood. Here too, the blood recipient's vein is best opened as described earlier. The simplest method of indirect transfusion with whole blood is probably with the help of a syringe. Blasius, Mosler and Martin have constructed their own syringes, of which Martin's is made entirely of glass, including the pump, which is wrapped with cotton thread every time before the syringe is used. When using it, there is nothing to fear from contamination by the syringe, it is 7" long, holds a good 2 ounces of blood, is transparent everywhere and can easily detect the presence of an air bubble and remove it before the operation. Martin (18) has a moderately curved trocar for the opening of the vein that is to be exposed earlier; it is $4^1/_2$" long, $1^1/_2$" wide at the top, and $^3/_4$" thick. The tip of the trocar is ground square, protrudes 2" in front of the opening of the silver tube; the handle is 3" long. The instrument is curved in an arc of 2" radius. The syringe and trocar are housed in a small portable case measuring 8" long and 2" wide. I have already spoken in a negative sense about the use of the trocar for the opening of veins. The process of indirect transfusion with a syringe is therefore to be carried out in the following way: after the cannula (Fig. 1, Plate 1) has been inserted into the vein of the blood recipient, a venesection is made on the arm of the blood donor and the blood is collected in a narrow beaker which is placed in a water bath at 37°C. A well-closing glass syringe, which has been warmed to around 40°C can be used to steadily absorb the blood from the beaker; any air bubbles that have been carried along are removed from the syringe by pushing the plunger forward leaving a spherical protrusion of blood at the mouth of the syringe. During this last manipulation, an assistant pulls the spine out of the venous cannula, tries to fill it with blood from the outside by stroking the vein against the direction of the current, or by means of a glass pipette drawn into a fine tip, until the free end of this cannula is also closed like a ball by blood. The mouth of the glass syringe, which is filled with warm blood, airless and ends with a free drop of blood, is inserted into the drop of blood protruding above the mouth of the venous cannula and the pump is evenly protruded. Then the spine is inserted into the venous cannula, the syringe is filled again and emptied in the same way, as long as the blood is liquid and until the desired quantity of blood is introduced. With this method, you can absolutely avoid the entry of an air bubble. Not as simply as this has been described here, Blundell, in his revival of transfusion in the years 1819-1829, performed indirect transfusion. Blundell used a complicated device for this purpose. The blood destined for transfusion was collected in a conical vessel in a larger funnel; from the top of the cone a tube led to a double-drilled adjustable tap. If the tap was correctly positioned, the blood could be sucked into a syringe connected to it, which could hold about 12 ounces, by pulling up the syringe plunger; then the tap was turned 90° and the syringe plunger was pressed down, then the blood was forced into a flexible outflow tube and from there through a venous cannula into the vein of the blood recipient, and this play of the pump in conjunction with the control of the tap was repeated until the transfusion was completed. Later, Blundell constructed his gravitator, which uses hydrostatic pressure as a motive force instead of syringe pressure. This is a funnel that opens into an elastic tube that can be closed with a tap and from this the blood can be pressed into the silver cannula. – C. v. Gräfe and Sotteau made only insignificant changes to Blundell's device. In 1853, Mathieu presented two new transfusion instruments to the Academy of Sciences in Paris, which Bouley (19) describes in a report he wrote to settle a priority dispute between Mathieu and Mancoq in the following words: "Dans le premier le moteur du liquide n'était autre qu'une sphère en caoutchouc vulcanisé, qui revenait sur elle même après avoir été comprimé. Le mémoir fait connaître le mécanisme nécessaire, pour que le liquide introduit par un tube ne puisse pas y refluer et suive le courant de l'autre d'où son reflux est également impossible." ["In the first, the liquid motor was none other than a vulcanized rubber sphere, which returned to itself after being compressed. The memoir makes known the necessary mechanism, so that the liquid introduced by one tube cannot flow back into it and follows the current of the other from where its reflux is also impossible."] This mechanism consists of two cone valves that open in one direction, which at the same time allow the instrument to act as a suction and pressure pump, "dans le second appareuil le jeu de la vessie en caoutchouc était remplacé par un corps de pompe destiné à imprimer le mouvement de sang de la veine qui le verse dans celle qui doit le recevoir" ["in the second device the play of the rubber bladder was replaced by a pump body intended to impress the movement of blood from the vein which pours it into the one who is to receive it"], and in 1866 he submitted a third apparatus to the Academy. It consists of a funnel for receiving the bloodletting blood; this funnel communicates through a flap that opens outwards and downwards with a glass pump boot, the plunger of the pump carries a channel that continues into an elastic tube.

When the pump's plunger goes downwards, the blood flows from the funnel into the pump; when the plunger is moved upwards, the blood is pressed from the plunger canal and into the elastic tube connected to it, and from there is transferred into the vein. It is superfluous to enter into a critique of these devices, since in fact they have no advantage over the indirect transfusion with the glass syringe, which is their complicated structure.

PART 2 – PAGES 47-68

The devices for indirect transfusion described by Richardson, Belina, Gesellius, and Leiter in the operation with defibrinated blood can also be used for transfusion with whole blood, although it is only to be remarked that the more complicated the device is in its handling, i.e. the more time it takes to put them together and put them into action, the less suitable they are for this transfusion, because the blood flowing out of the vein in contact with the atmospheric air and with the glass wall coagulates relatively quickly and becomes unsuitable for transfusion, even if one takes the care to keep the transfusion devices blood-warm. On this occasion I cannot refrain from calling attention to a fact which is misinterpreted by most surgeons. Almost all surgeons require that the blood to be transfused should be used as warm as blood, and many believe that this temperature is necessary to prevent the clotting of the blood; but in this they are mistaken. Hewson has already shown that freshly released blood, if it is kept blood-warm, i.e. at 37°C, coagulates relatively earlier than if it is exposed to the usual room temperature. The reason why all surgeons require the blood to be transfused to be at a temperature of 37°C, therefore, cannot be the preservation of the fluidity of the blood, since blood at a low temperature would better suit this purpose, but the surgeon takes the liberty of adding another incalculable factor to those already existing by the transfusion of cold blood. We have no idea at all how the entry of cold blood into the vein and the right atrium acts, whether and in what extent reflex actions are evoked, and whether and to what extent the effect of the shock is thereby increased, and therefore it is advisable, as long as these conditions are not known, to transfuse the liquid at blood temperature. I have no courage to test these conditions in humans, but I have only obtained negative results in animals. I have artificially bled rabbits to death by cutting their carotids and catching the blood flowing out in a beaker placed on ice; then I transfused their own strongly cooled blood through the jugular vein; I have not succeeded in bringing the animal back to life in this way. Nicolas Duranty (20) is said to have succeeded in similar experiments, which is why he recommends this method for humans as well. For the reasons given above, I cannot comply with this recommendation, because it is incorrect that low temperatures avoid clotting altogether. Experiments that I have done with pig and rabbit blood, which were collected in beakers enclosed in ice, have shown that such blood clots relatively quickly. The clots are soft and sparse and are overlooked on superficial observation; but it is precisely the presence of soft and easily missed clots that make the method of transfusion with cold blood appear useless, even apart from the possible reflex phenomena. On the other hand, a cooling of the blood by 6-10°C has no perceptibly harmful consequences. It is therefore not absolutely necessary to anxiously insist on a temperature of 37°C for the blood to be transfused.

It seems to be advisable for the indirect transfusion with whole blood, no matter what device is used, to drain only 20 to 40 gm of blood from the blood donor at a time, exactly as much as one wants to inject into the blood recipient in the unit of time (about half a minute), and to repeat the manipulation until the previously described quantity of blood has been transfused. If one exercises this caution, then one will not be forced into transfusing larger quantities of blood in a relatively short time, and on the other hand, will not have to contend with premature clotting of the blood. When healthy blood leaves the vein, it never takes less than 100 to 120 seconds to clot; this time is sufficient to transfuse 20-40 gm without haste. If the time from the exit of the blood to the entry of the blood into the vein of the blood recipient is more than 2 minutes, then how long the blood remains liquid will depend on the individuality of the blood donor. 8 minutes is probably the limit that the blood can remain outside the vessels in a liquid state. All methods that take a long time are therefore unsuitable for transfusion with whole blood. It is to be mentioned here that from my observations I consider myself justified in concluding that all the emotional effects of the blood donor, such as fright, pain, etc., alter the blood in such a way that it coagulates relatively more quickly; therefore it seems advisable to place the blood donor in such a way that he does not see the stream of blood from his own arm, and to divert his attention during this time. It has happened to me repeatedly that the blood donor fainted at the sight of the jet of blood. The shock and excitement of the blood donor during the blood donation about the surgical procedure seemed to me to be equally detrimental to the coagulability of the blood, and therefore I think it expedient to engage the blood donor's attention during the operation and to divert his thoughts away from the operation.

In the methods described so far, the blood was always exposed to the air before it was transfused; it is now our task to discuss the transfusion with whole blood in the exclusion of air, i.e. directly from vein to vein. One would think that with the low pressure under which blood is under in the veins, a direct transfer from vein to vein is not possible at all; but this is not the case. We have a whole series of methods in which the direct transfusion from vein to vein has been carried out in humans. - Dr. Paolo Postempski (21) in a work that won a prize in Rome (La transfusione del sangue 1870) described a device by means of which anyone can perform the direct transfusion even without assistance. This consists of two lance cannulas, which are connected by a rubber tube. The phlebotomy bandage is first applied to the arms of the two individuals, the blood-giver and the blood-recipient, thereby making the veins bristle. The lance cannula is inserted centrifugally into the blood-giving vein, and centripetally into the blood-receiving vein of the second individual. The infusion cannula is inserted only after the rubber tube and the two cannulas have filled with blood from the blood-giving vein. According to Postempski, this method should be able to accurately calculate the amount of blood flowing over. If one remembers how many seconds have elapsed from the moment of the puncture into the blood-giving vein to the filling of the rubber tube and both cannulas, and if one knows the volume of the device, one knows that in a certain time a certain quantity of blood flows over. From the number of seconds during which one has transfused, one should then be able to calculate the quantity of blood that has flowed over by a very simple proportion. Menzel has already pointed out that such a calculation has no value at all, and I believe that with the method according to Postempski it is not even possible to give an approximate indication of the quantity of the transfused blood; but this suggestion should not be completely rejected on that account, and one could console oneself for the defect of the method if one could only carry out a successful transfusion with the instrument. The instrument is very simple, and can easily be improvised at any moment. It is only necessary to join together two needles, such as are used for Pravaz's syringe, and a correspondingly thin, non-perforated drainage tube (an aid which every doctor possesses), and then the Postempski transfusion apparatus is ready. With this method, however, there would be nothing to fear from shock or blood overfilling the right heart, and air entry would also be out of the question. But the question arises whether the method is at all reliable enough, in other words, whether the constriction of the arm of the blood donor is sufficient to increase the low velocity or compressive force of the venous blood through the blood stasis in such a way that the existing resistance is overcome and clotting is prevented. As I have not yet had an opportunity to test this method in humans, I cannot presume to make a reliable judgment, but I believe that in the short time of the blood flowing through the rubber tube and through the two cannulas, clotting will not take place, and as soon as the blood has passed through the improvised apparatus and has reached the vein, then there is no longer any need to fear subsequent clotting. Nor does it seem to me to be subject to any difficulty in increasing the venous blood pressure, which has been increased by the constriction of the arm, by the significant amount through aid of the gravity of the blood. It is only necessary to place the arm of the blood recipient 0.5 to 1.0 metres below that of the blood donor, in order to add to the existing blood pressure the hydrostatic pressure of the blood column to be transfused, which should probably be sufficient to remove the obstacles in the vein and also to conduct the blood quickly enough over the inorganic connecting pathway between the two veins to prevent blood from clotting. Therefore, although I must generally speak out against the opening of veins by needle devices or trocars, I shall nevertheless taking into account the simplicity of the transfusion device, it is easy procurement and handling without any assistance, and in view of the slight injury to the veins of the two persons involved in the transfusion, this method of transfusion should be tested as soon as the opportunity arises.

In 1862 Mancoq specified the following device for the direct transfusion from vein to vein in humans: A glass cylinder mounted to a pump, which at its lower end has an opening on two opposite sides with a flap valve moving in the same direction, has thin rubber tubes attached to these openings, and small silver tubes are attached to the end of the rubber tubes. If the silver tube, which communicates with the flap valve opening into the pump chamber, is inserted into the open vein of the blood donor and the plunger of the syringe is drawn up, the pump sucks the blood out of the vein into the glass cylinder and when the blood is pressed down into the tube through the opposite flap valve, which opens outwards from the pump in the opposite direction, and with the help of the trocar tube, which has been inserted into the vein of the blood recipient. In 1866 he chose a hollow needle in place of the trocar to be inserted into the vein, which can miss the venous space, the cavity of which extends from the thicker end to the middle of the needle and opens there with a lateral opening. The vein of the blood recipient had to be pierced with this needle and pushed forward until the lateral opening of the needle came to rest in the lumen of the vein on the central side of it, and the pressure tube of Mancoq's pump was inserted into this hollow needle during the transfusion. It is clear that the hollow needle does not represent an improvement on the original device. Some successful transfusions are said to have been carried out with this instrument, and Behier (22) is said to have used the device to bring to life and preserve a young woman who was near death due to an unstoppable uterine haemorrhage. However, I cannot speak in favour of Mancoq's device, neither the original nor the device supposedly improved in 1866 by the hollow needle, because the same idea of interpolating a pump between the veins of the blood donor and blood recipient, which works at the same time as a suction and pressure pump, and can be carried out in a much easier and more convenient way than by means of a complicated and expensive pump, which is set in motion by means of a toothed rod and a gear. All you need is Demme's syringe as described above (Fig. 2, Plate 1), the blood is sucked in each time the plunger is drawn up and pressed in to the opposite side when it is pressed down. - It is a great advance to make the pump interpolated between the two veins, acting as a suction and pressure pump, out of rubber, something like the one shown in Fig. 15, Plate 4 in natural size and will be described in more detail later. Aveling (23) and his followers have made the direct transfusion from vein to vein in the manner just described. All of these methods make it possible to determine exactly the quantity of transfused blood; it is only necessary to ascertain empirically how many grams or cubic centimetres of blood correspond to a plunger stroke or a compression of the rubber pump, and then to note the number of piston movements in the transfusion in order to be able to determine the quantity of the whole blood transfused with the same accuracy as in the indirect transfusion.

In all the methods of direct transfusion described so far, there is the disadvantage that one must place the imposition on the blood donor must be expected to have a cannula inserted into his open vein and to leave it there for the duration of the transfusion, an imposition to which a blood donor will not easily consent; for even if the insertion of the cannula into the vein is not exactly associated with a danger to life, no one will deny that the manipulation of the insertion of the cannula is a stimulus which prolongs the healing of the venous wound not insignificantly and is associated with pain during the operation and perhaps also during the healing of the venous wound. It must therefore be the surgeon's endeavour to minimise the injury to the blood donor’s vein, and this is obviously only the case if the vein comes into contact with a foreign body as little as possible; we cannot spare the blood recipient the small inconvenience of inserting the cannula into the vein; he must accept this evil with the other evils of the operation to regain health, but in the case of the blood donor, the venesection and the blood, shed in the process, seem to be the greatest measure of willingness to sacrifice that we may address of him, and that is the reason why the direct transfusion from vein to vein in spite of the large number of suitable ingenious and simple devices has not found much application so far.

In 1873 Dr. J. Roussel of Geneva constructed an instrument which he called the hermetic transfusor, which permits the direct transfer of the whole blood from vein to vein without bringing the vein of the blood-giver into further contact with a foreign body after it has been opened as in the ordinary venesection, and because the blood, which is used for transfusion never comes into contact with atmospheric air, he attaches to his transfusor the adjective of the hermetic. - Roussel achieves what was otherwise achieved by inserting a cannula into the vein of the blood donor, by sub-aqueous venesection, and by sub-aqueous transfer of blood into the blood recipient's vein. Fig. 12 (Plate 4) represents Roussel's transfusor during transfusion, which I will explain briefly. *G* represents the arm of the blood donor, *E* that of the blood recipient, *S* a cupping head made of hard rubber, which is intended to be placed on the veins of the elbow bend. It is kept firmly on the skin by the aspirator *A*. For if the rubber balloon *A* is compressed in the hand, and the air is expelled from it, the cupping head is pressed on the skin, and then released, it assumes its former shape by virtue of its elasticity, and therefore aspirates the air from the cupping head *S*, and holds it in its place for any length of time. The cupping head *S* is shown in Fig. 12 (Plate 4) as if a piece of its wall had broken off in order to be able to look into it. It can be seen that the cupping head is not quite hollow, but has a cylinder *C* in its centre; therefore, not the entire cupping head, but only the cavity located between the cylinder and the mantle surface of the cupping head can be made vacant. The cylinder *C*, which is hollow and makes the skin together with the veins contained in it accessible and visible to the naked eye from above when the cupping head is attached, can be closed by the pusher *D*, which bears the lancet *L* at its end. *P* is a rubber pump with two flap valves opening in the direction of the arrow; *W* is a water container with the connecting pipe *r* and with the tap at *H*. The process of transfusion is as follows: The instrument is heated by immersion in warm water, and then the cupping head is placed over the median cephalic vein or basilic of the limb, which is constricted on the upper arm and pressed firmly in the crook of the elbow by squeezing the aspirator. One can now see the direction of the vein from above through the center of the cupping head and can direct the lancet *L*, which is attached to the pusher *D*, as desired in order to cut the vein obliquely or transversely. The pump *P* is now compressed, the air is expelled, and the whole apparatus, with the exception of the cavity of the cupping head enclosing the cylinder *C*, is filled with water from the vessel *W* through the tube *r*. Now the trigger *D* is pressed down with a blow and the lancet is pushed into the vein and the same is opened sub-aqueous. The tap at *H* is turned over and further communication with the water is shut off. The blood flowing out of the vein mixes with the water and, if the blood pressure is higher, would flow automatically towards pump *P* and flow on from there. If the pump *P* is now pressed together by hand, the blood, rushing the water in front of it, is sucked into the pump and then pressed away. At *g*, a glass tube is switched on, which shows the arrival of the blood as well as the presence and absence of air bubbles. (24) If the venous cannula (Fig. 1, Plate 1) is now inserted into the arm of the blood recipient, the transfusion can begin as soon as the spine is pulled out and the cannula is filled with blood. With Roussel's transfusor, each pressure of the pump corresponds to about 10 gm of blood. I have carried out a total of about 12 transfusions with this instrument, and consider myself entitled to a competent judgment on the advantages and disadvantages, which I will briefly mention here. With Roussel's transfusor, a direct transfusion can indeed be made without the need to irritate the vein of the blood-giver by inserting the cannula, and yet the blood flowing out of the vein does not come into contact with the atmospheric air; only the first part of the venous blood entering the apparatus comes with a $^1/_2$ percent saline solution or a two-proc. carbonated soda solution. One can transfuse with the instrument without fear of coagulation so slowly that the 10 gm which the balloon holds only reaches the right heart in 10 seconds. There is no need for medical assistance for this transfusion. The instrument can also be used to accurately determine the quantity of the blood transfused; one can immediately recognize any clotting that has occurred in the device because the pump is failing to do its job. Finally, I would like to mention that it is possible to save on the amount of blood of the blood donor, and that he does not see the blood at all. The disadvantages of the apparatus consist in the difficulty of the sub-aqueous opening of the veins of the blood donor; it takes practice and experience to open the vein sufficiently wide at the first time and yet not to injure the opposite vein wall or even an artery. The flute in the cupping head is adjustable, i.e. it can be made longer and shorter; such a locomotion of the flute is sometimes necessary, because the cupping head sometimes presses itself quite deep into the soft tissue; therefore, out of prudence, it is better to shorten the flute, and then not reach the vein immediately. In general, the cupping head with the flute in the centre remains the weak side of the instrument. It has at least cost me a great deal of effort before I have decided to open the vein without control of the eye, and there is no means of removing this evil; only the other advantages of the apparatus could reconcile me to it. The interpolated glass tube *g* (Fig. 12, Plate 4) cannot give any information as to whether the blood is still liquid or clotted. Cleaning the device is cumbersome, as will be shown later. I used to think that it was a great evil that the material of the apparatus, the rubber, would be exposed to deterioration; but since I have had the opportunity of observing devices made of natural rubber and of the English pink rubber, which have been exposed to different temperatures and almost always to the air over the course of 2½ years, and yet had lost nothing of its usefulness, I must greatly soften my judgment of the deterioration of the material; however, how long the rubber will remain usable without becoming brittle, I cannot pass judgment on that.

I have already repeatedly argued against transfusion through the arteries, both when the transfusion is into the main trunk (brachial artery) and into the terminal branch (radial or tibial branch) of an artery. It will therefore suffice to remark that the majority of those transfusion methods described so far with whole blood - including the method of direct transfusion with Roussel's transfusor - can also be carried out in the case of transfusion into the capillaries through the end of the artery; on the other hand, I do not think I should mention the technique of direct transfusion from artery to artery in man, because in my opinion such an operation is not permissible at all. If such a suggestion is made to him, the doctor is obliged to reject it, to inform the persons concerned about the dangers involved in the operation and about the limited benefit it has to show before the transfusion from and into the veins. It is no stranger to me that this method of transfusion has been advocated and recommended in recent times; however, I have firm confidence in the sound judgment of general surgeons and I am convinced that direct artery-to-artery transfusion will never become common practice in humans, so I consider it unnecessary to oppose the proposal.

I now proceed to the transfusion with animal blood. I have to mention here that I have always used adult sheep and never lambs. (25) Lambs are bound to a certain season, while sheep are available at any time; therefore, in view of my purpose of being able to use animal blood transfusion for those who have become anaemic on the battlefield, where there are only sheep and no lambs, I had to use sheep for my preliminary studies. But if the choice is free, then lambs are decidedly preferable, especially when, as in my case, it is a question of phthisis or the treatment of chronic anaemia or some other disease of exhaustion, because the effects of lamb blood transfusions differ in some respects essentially from those of sheep blood transfusions. It is true that in this discussion we touch upon a dark and as yet unexplored area of comparative physiology, but the facts which we need for our purpose are beyond doubt. Everybody knows that animals give off their own smell peculiar to them (horse, goat, sheep, etc.). All that is known about the source of these peculiar olfactory substances is that they come from the group of volatile fatty acids, caprylic, capric, capron and other acids, and that by way of secretion and excretion. But since this group of fatty acids, or at least several of them, can be represented by treating the blood of the animals mentioned with sulphuric acid, it is justified in the assumption that these fatty acids are contained in some compound preformed in the animal blood (Lehmann). Further, it will hardly be a mistake to suppose that these volatile fatty acid compounds in the blood are, among other things, chiefly caused by the food of the animal (herbivores and carnivores, corn-eaters, grass-eaters, and fruit-eaters, etc.), and that animal blood impregnated with fatty acid compounds, when transfused into the blood vessels of man, will produce the objective and subjective symptoms described above. The lamb is not yet a herbivore, it feeds on its mother's milk, and therefore the above-mentioned volatile fatty acid compounds will be present in the lamb's blood in smaller quantities or in a different composition, and therefore they will also cause much milder symptoms of disease when transfused in humans. It is also evident that the lamb's heart needs less work than the sheep's heart in order to carry on its circulation; in other words, the pressure in the carotid artery of the lamb will be much less than that in the carotid of the adult sheep; and if the lamb carotid artery is connected with the human vein, the lamb's blood will flow into the human vein more slowly, in smaller quantities, and will therefore also inhibit the return of the venous blood from the flow area of the superior vena cava less than is the case with the inflow of the carotid blood of the adult sheep into the human vein. So the shock, the overcrowding of the right heart and the backflow of the venous blood to the central nervous system will be less than in the case of transfusion from an adult sheep. Finally, it will not be mistaken to suppose that the blood of the lamb contains a greater sum of elements for the structure of the animal's body, in short, plastic elements, than the blood of the full-grown sheep, and that this benefits the body exhausted by chronic anaemia or other diseases. All the circumstances just mentioned speak in favour of the use of lamb's blood for transfusion. For the reasons I have given before, I have used only adult sheep for transfusion, and it will now be my task to present the most expedient method of transfusion with sheep's blood. I must, however, begin by explaining what I find wrong with the simple methods indicated by Hasse (26) and Gesellius (27), and why I have abandoned these methods, and more correctly, never used them.

I have first of all a serious word to say against the use of glass in cannulas, both for the carotid artery of the sheep and for the human vein. The glass cannulas are buttoned in both Hasse and Gesellius, i.e. the glass tube tapers at its end and then swells into a button which is inserted into the vessel lumen. At this point, however, the glass cannula is very fragile; any sudden movement, a push, a pressure is enough to break off the glass tube at its neck (behind the button), whereby not only does it impair the course of the transfusion, but also exposes the person (including the sheep) to great dangers; the blood also clots in the glass tube as soon as the transfusion is interrupted for the purpose of slow blood flow. A further reproach which I have to make of the two simple methods of Hasse and Gesellius, which I have mentioned, is that with the devices one is not only unable to specify the quantity of transfused blood, but one is even unclear as to whether blood overflows at all. It is usually supposed that coagulation is the only factor which prevents the overflow of blood; therefore, if the blood is found liquid after the interruption of the transfusion, it is concluded that blood has overflowed during the whole time before the interruption; but this is a fallacy that can be enlightened by experimental means. For the vein exposed to the transfusion can be completely compressed in its course in a central direction for 2 to 3 minutes, so that it is impassable for blood without the blood having to have clotted on that account, and when the transfusion is interrupted, the blood will flow quite normally from the cannula in the carotid column, and yet the blood there has been at rest before the interruption of the transfusion. There is also the transparent wall of the glass cannula. As there is no indication at all of the good progress of the operation, because the appearance of the blood in the glass tube is always the same when the blood is moving and at rest, and when the blood is completely coagulated, a deception in this direction is very easily possible, and I believe that this deception may have occurred quite often, and that in some animal blood transfusions undertaken by these methods, little or no blood has penetrated into the right heart. Not even the occurrence of the objective and subjective symptoms described can give a definite indication that a large quantity of blood has been transferred; for it is quite possible that the simple touching of the heart or the inner vessel wall with the volatile fatty acids present in animal blood can produce cyanosis, dyspnoea, and pain in the various regions in a reflective way. Many of the objective and subjective phenomena of transfusion previously described, therefore, may have been perceptible, and yet the animal blood may have penetrated only as far as the right atrium, because for some reason it was unable to penetrate any further.

According to what has been said so far, I believed myself justified and obliged not to follow in the footsteps of Hasse and Gesellius in the transfusion of animal blood, but to go my own way, not losing sight for a moment of the purpose of being able to carry out the transfusions of animal blood on the battlefield. For this purpose I have constructed a cannula for the carotid artery of the sheep, or of the blood-giving animal in general, which makes it possible to prepare this part of the transfusion far from the field of battle, or to have it prepared, so that in the given case the blood can be transfused immediately to one or more wounded in need of blood without any operation by the same animal.

Figs. 13 *A* and *B* (Plate 3) represent the cannula for the animal carotid in natural size and in average length. *A* shows the cannula as a solid body when closed, *B* with the plunger wound up. The cannula itself is a tube with a lateral branch; the straight part of the tube can be closed completely or only as far as the junction *z* by means of a punch or rod *s*, which is guided and moved by means of the knob *k*. The rod *s*, which, like the whole instrument, consists of polished hard rubber, is made of nickel silver or brass in its rear part *m*, and carries a spring *f* which presses against the wall of the cannula, and has the purpose, when the plunder *sm* is pulled out by the knob, to spring up on the screw spindle, whereby an accidental pushing of the rod back or forward is prevented; if you want to push the rod back into the tube, you must first press down the spring so that it can pass through the protruding screw spindle at *V*. On the other hand, the screw *V* serves to prevent the rod *s* from being extended further than the limit *g*. The cannula is now bound into the carotid artery with the plunger inserted, as shown in *A*, in such a way that the end *b* of the instrument lies in the central part of the carotid, and the thread is knotted behind the swelling. Thus prepared, the cannula may lie in the carotid for several hours, and the animal may be transported miles with the cannula bound into the carotid. At the moment of need, the rod is retracted at the knob *k* to *g*, then the cannula forms a curved cavity *ba′*, which has no angle or furrow anywhere, and into which the blood of the carotid will immediately pour; if a rubber tube *k′* with the attachment *m′* is mounted on this free end *a′*, the carotid blood will flow from *b* towards *a′* and then further in the direction of the arrow. If you want to interrupt the transfusion, you only have to press down the spring at *f* and push the rod *s* to *b* forward again, then not a drop of blood can escape from the carotid, and you only have to wipe out the blood from the branch tube *z* with a suitable wiper to have the instrument ready for a second transfusion and this can be repeated until all available blood is used up.

Blood can be transferred from a full-grown sheep to at least four persons in need of blood, provided that the animal has not lost too much blood during the operation of exposing and opening the carotid artery. Here, too, the extreme limit of the permissible borrowing of blood in the animal may be $^1/_{20}$ of its body weight, i.e. if the sum of the blood which the animal has given or otherwise lost to those in need of blood is $^1/_{20}$ of its body weight, then one may no longer borrow blood from the animal for transfusion purposes, because the blood now borrowed can no longer be borrowed from a living, but comes from a dying animal. Incidentally, it is still questionable whether, with such a considerable loss of blood, it is still possible to extract blood from the animal using a device.

From what has been said so far, it is evident that even in the field the transfusion of animal blood is very easily carried out with great speed and on a large scale. In the case of a number of sheep, it is only necessary to expose one carotid artery and to use the cannula just described (Fig. 13, Plate 3) into it. This operation may be performed one or more hours before use and at a place distant from the place of use as a preparatory act for the transfusion. In this case, the branch of the cannula is closed accordingly, the whole cannula is lowered into the depth, and the neck of the animal is bandaged with a compress and protected against harsh conditions. If, at the place of need, a vein in the arm of the wounded individual is now exposed and the cannula (Fig. 1, Plate 1) is placed in it, then if the work is properly organized, if, for example, only 10 sheep with cannulas are available in the carotid, the animal blood transfusion can be carried out on 40 wounded with acute anemia in a period of about 2 hours, i.e. a performance quite appropriate to the circumstances.

We have spoken of the carotid cannula, and now, according to the method of Hasse and Gesellius, we could now transfuse by a simple interposition of a rubber tube. These authors believe that they can determine the quantity of transfused blood by determining the quantity of blood that comes out of the carotid in the unit of time (one second) before and after the transfusion, taking the remedy from it, and multiplying the number thus obtained by the number of seconds during which the transfusion was in progress. However, I have become convinced myself that this determination is quite unreliable, as will be shown presently. In fact, in order to avoid the cumbersome determination of the quantities of discharge before and after the transfusion, I believed that I could measure the quantity of blood transferred during the transfusion in the following way during the operation. I assumed that with the same hydraulic pressure the quantity of an out-flowing liquid was proportional to the cross-section of the outflow pipe, and I imagined a tube made of hard rubber with a lateral branch (Fig. 14, Plate 3). The variety of cross-sections varied in the individual tubes. Such a branch tube was switched on in the direction of the transfusion current near the arm vein in such a way that the main tube *H* at *k* was inserted in the central part of the rubber tube, at *k′* in the peripheral part of it near the venous cannula, while the branch *a* at *k″* was led into a rubber tube and connected with a venous tube of the same size, which ended in a vessel under a 10 mm high mercury column. I believed that by this means the outlets of the main and branched tubes were under equal proportions, and then the quantities of outlet from the main tube *H* and the branch *a* should be proportional to the relevant cross-sections, or, what is the same thing, to the square of the radii concerned, and because I could measure the quantity of blood flowing out of the narrow tube during the transfusion period, I thought I could calculate the amount of transfusion blood from this. But even the first attempt showed me that my assumption was untenable and showed me that even in this way the quantity of transfused blood could not even be approximated. In experiments which I have carried out with this dichotomous tube with water and with free discharge of both end tubes, I have found that the assumption that the quantities of outlet are proportional to the square of the radii in question is only valid if the duration of the experiment is longer, and then only if the pressure size remains unchanged and the resistances remain constant. In the case of a direct blood transfusion, which lasts a maximum of 1-1½ minutes, where, moreover, the pressure magnitude (heart force) continuously fluctuates, and where the resistances in the new pathway vary unpredictably, absolutely no reliable conclusion can be drawn about the amount of blood transfused in this way. I have therefore come to the conclusion that in the direct transfer of the blood, as described here, and as Hasse and Gesellius have explained, the determination of the quantity of the transfused blood can only be obtained by an exact weighing of the recipient of the blood and the blood-giving animal on an exact scale, a method which is not to be used in practice. I therefore had to look for another method that would allow me to determine the quantity of directly transmitted blood during the operation. L. Noël (28) has tried to solve this problem in a very ingenious way by rolling up the rubber tube connecting the two cannulas in a circle; by means of a pressure device attached within the circular coiled rubber hose, one part of the hose can alternatively compress one part of the tube after another; accordingly, liquid is squeezed out to the side where the pressure progresses and liquid is sucked in, in the opposite direction. It is therefore possible to ascertain by experiment the quantity of the liquid corresponding to a complete revolution of the circle, and then it is only necessary to count the sum of the revolutions in order to be able to determine the quantity of the liquid squeezed out. This idea of converting a hose rolled up in a circle into a suction or pressure pump by successively compressing it, I have already seen in use in a portable fire engine, and the device may also be used for transfusion. However, since it has not yet been used for this purpose, as can be seen from the author's statement, I thought it more appropriate for my circumstances to stick to a measuring apparatus that I had already tried elsewhere, and therefore I also used the English gastric pump indicated by Schliep (29), which he switches on between the blood transmitter and the blood receiver and which also serves as a suction and pressure pump, was not used and preferred to use the pump known from Roussel's hermetic transfusor. This pump, which in its essence was already used by Mathieu (30) and still earlier by Seott (31), I will call the Roussel pump, as it has been modified in its details by Roussel. The same is shown in Fig. 15 Plate 4, shown in natural size on average. *bbbb* is the average length of the oval body of the pump, which is open on both sides. The openings are solidly mounted by two hard rubber pieces screwed together, one of which *i* protrudes into the opening of the pump, the other *e* protrudes outwards from it. On each side of this mount is screwed an attachment piece *a* made of hard rubber, which is used to connect the rubber hoses *k* and *k′*, but also to enable access to the two flap valves (made of rubber) *VV′*, which can be moved in one direction. If the pump body *bbbb* is now compressed in the palm, the valve *V′* opens and drives the liquid in the direction to *k*; if the pressure decreases, the compressed pump wall rises by virtue of its elasticity, valve *V* opens and liquid flows into the pump. This pump is more compact, easier to handle and cheaper, and therefore preferable to any other.

My apparatus for the direct transfusion of animal blood therefore consists of the following three parts: 1) the carotid cannula (Fig. 13B, Plate 3), 2) Roussel's pump (Fig. 15, Plate 4) with the rubber hoses attached to both ends of it, and, 3) the venous cannula shown in Fig. 1, Plate 1. (32) An apparatus for the transfusion of animal blood thus assembled has the following advantages:

1. It permits the division of the transfusion work to the fullest extent. The work may be entrusted to three doctors independent of each other, both in space and in time; one doctor has only the task of integrating the cannula into the animal’s carotid artery, a second of placing the venous cannula with the spine into the vein, and the third of the transfusion to connect the two cannulas together.

2. It allows a reliable judgment to be made about the course of the transfusion and about the quantity of the transfused blood. If the obstacle to the removal of the transfusion blood is small, then the pump will also be able to be moved with little effort, while if the obstacles in the vein grow, the pressure for the movement of the pump must also increase. When the blood finally clots, the pump fails to do its job completely. The complete emptying of the material in the pump shown in Fig. 15 Plate 4 corresponds to 10 gm of blood. 10, 15 or 20 compressions of the pump therefore correspond to a transfusion quantum of 100, 150 and 200 gm.

3. The device makes it possible to interrupt the continuity of the incoming blood and to moderate the speed of the blood flow, thereby preventing overcrowding of the right heart and the shock. If the pump is gradually compressed, and it is only allowed to expand just as gradually, it is not difficult to extend this manipulation to 20 seconds; if a break of 5 seconds is made between the filling of the pump and the compression of it, then 10 gm of blood has been injected in 25 seconds, i.e. such a low transfusion velocity as to prevent the reflux of venous blood, nay, one may double the velocity of the transfusion flow and go so far as to inject 10 gm of blood in 10 seconds, without having to fear causing disturbances in the blood flow and in the central nervous system. The device also draws the surgeon's attention to the fact that if the pressure to move the pump increases, there is an obstacle somewhere to the removal of blood, and that if it is not to be found on the outside of the vein in the arm, it should be located in the right heart, and that therefore the progress of the transfusion should be delayed or that it should be stopped altogether.

However, I must also report on a disadvantage of the device. As long as one works with defibrinated blood, any transfusion apparatus is easy to clean, but as soon as one transfuses whole blood, whether human or animal, the purification of the device, depending on its construction, is difficult or impossible to carry out, because the fibrin of the blood forms a solid, then shrinking clot, which extends into every joint and is very difficult to remove from it. Also in the pump (Fig. 15, Plate 4) such blood clots are lodged in the joints *ffff* which cannot be removed by the most careful washing and cleaning of the pump. In order to be able to clean the pump from these clots, it is necessary to dismantle it completely each time, i.e., the attachments *a e* and *i* in Fig. 15, Plate 4, then there is no longer an inaccessible or invisible joint anywhere, and then the pump can be completely cleaned, which is not the case to the same extent with other pumps consisting of boots, pistons and delivery. Unfortunately, I had to pay very dearly for this experience due to a sudden onset septicemia. I searched in vain for the infection site for a long time until I found it in the joints *ffff* of the pump in the form of dried and decomposed blood. The dismantling and reassembly of the pump can be easily carried out by hand without any auxiliary instruments.

I still have a few words to say about the binding of the cannula (Fig. 13, Plate 3) into the sheep carotid. Proceeding from the established fact that fear, fright, combined with pain, exerts a very significant influence on the operation of the principal organs of secretion (Claude Bernard (33) has shown that in painful operations, in vivisections, the secretion of the kidneys and certain other glands is impaired), I could not help thinking that the operation which is necessary in order to expose the carotid artery and to bind the cannula into it, is such an operation as to impair the urinary and other secretions, and that, in consequence, the blood of the animal, under the influence of these retained substances, appears less useful for transfusion than normal blood, which has given up the secretory constituents in the usual manner. I have therefore endeavoured to remove this influence by anaesthetising the sheep with chloroform in the usual way before the operation by means of the Skinner-Esmarch device; in this way I believed not only to prevent the harmful influence of the retention of certain chemical compounds in the blood intended for secretion, but also to reduce the compressive force of the heart in the blood-giving animal by anaesthesia, and thereby to moderate the overflow of blood and the shock in the blood-recipient, and at the same time to take into account the principles of humanity and one's own needs, and to protect the animal from fear and fright. I must emphasize that I have always used only a chloroform atmosphere strongly diluted with air for anaesthesia. The air inhaled during the anaesthesia of the animal contains at most 5 per cent chloroform, and this small chloroform content of the air does not have a detrimental effect on the blood. I have repeatedly examined the blood of chloroformed individuals (both human and animal) microscopically for the change in the blood cells pointed out by Hueter, to no avail. What was new was the observation that the sheep produced respiratory noises during anaesthesia, which had the greatest resemblance to crying and sobbing, and which were understood by the bystanders as crying and sobbing, although as far as I know, the only expression of pain in these animals is blocking, but not crying.

So I began to chloroform the sheep, as soon as the anaesthesia had occurred, I sheared the wool in the lateral neck area of the animal, and made an incision 7, at most 8 m, according to the direction of the sternocleidomastoid muscle. The exposure and isolation of the sheep carotid artery does not differ significantly from the same operation on the human carotid artery, and can therefore be assumed to be known and ignored here. For the less experienced, it may be noted that the sheep carotid has a relatively thin tunica media and therefore does not look quite and feel quite as light, nor does it feel as coarse as the human carotid. In spite of its bluish-red shimmer and its thin, delicate wall, there is no reason to fear that it will be misjudged, since it is sufficiently recognizable by its anatomical position and its pulsation. When the carotid artery is exposed and about 2 cm insulated, a double ribbon of thread is passed under the carotid. Now the carotid artery is gently compressed at the central part of its isolation with an ordinary anatomical tweezers, the branches of which are covered with rubber tubes (drainage tubes); then the peripheral end of the insulated carotid artery is firmly knotted with one of the two threads. The carotid artery is lifted upwards using this ligature suture and a fold is cut with fine scissors centrally on the artery and the cannula (Fig. 13, Plate 3) is tied in with the second thread; only now is the anatomical tweezers mounted with rubber, lifted and withdrawn.

PLATE 1

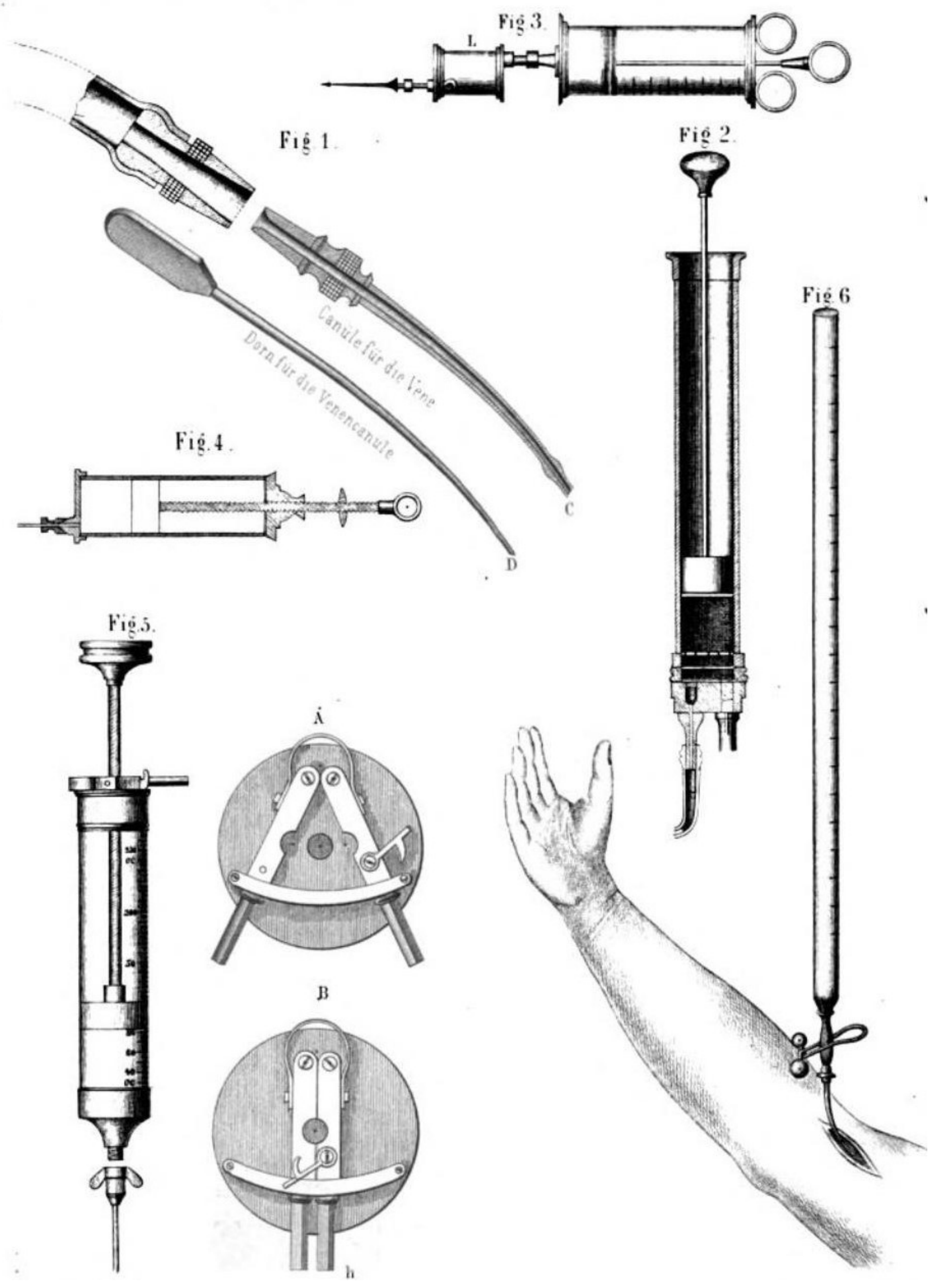


Fig. 3.
L
Fig. 1.
Fig. 2.
Canüle für die Vene
Dorn für die Venencanule
Fig. 6
Fig. 4.
C
D
Fig. 5.
A
B
h

PLATE 2

Fig. 8.

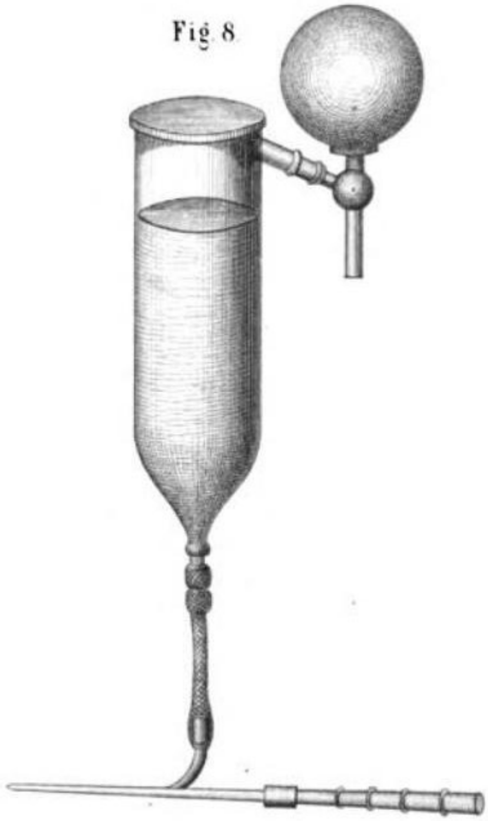


Fig. 9.

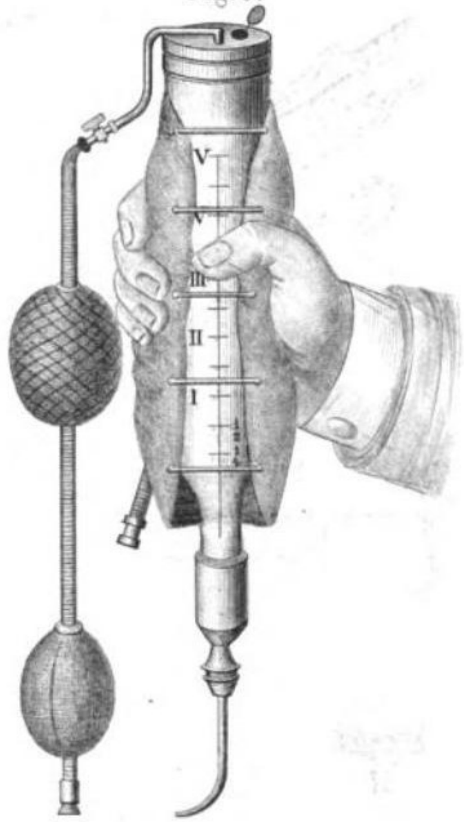


Fig. 7.

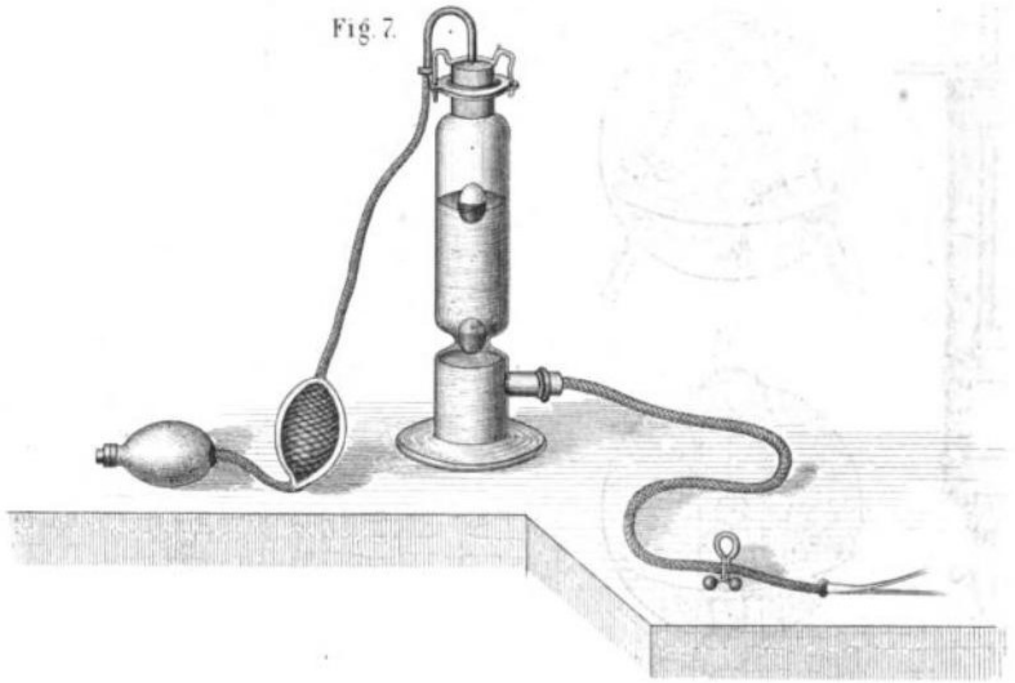


PLATE 3

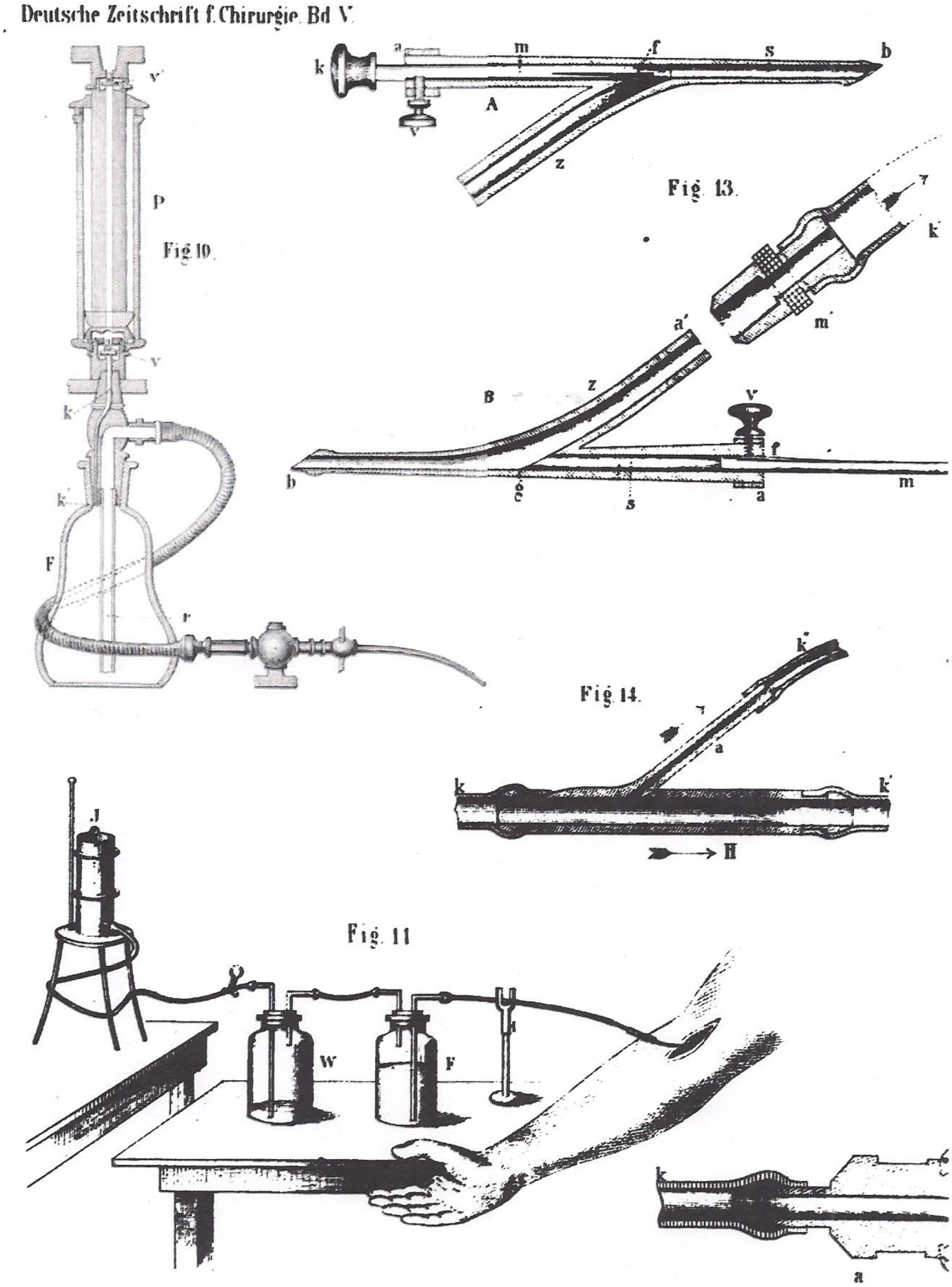

Deutsche Zeitschrift f. Chirurgie. Bd V.
Fig. 10.
Fig. 13.
Fig. 14.
Fig. 11

PLATE 4

Fig. 12.

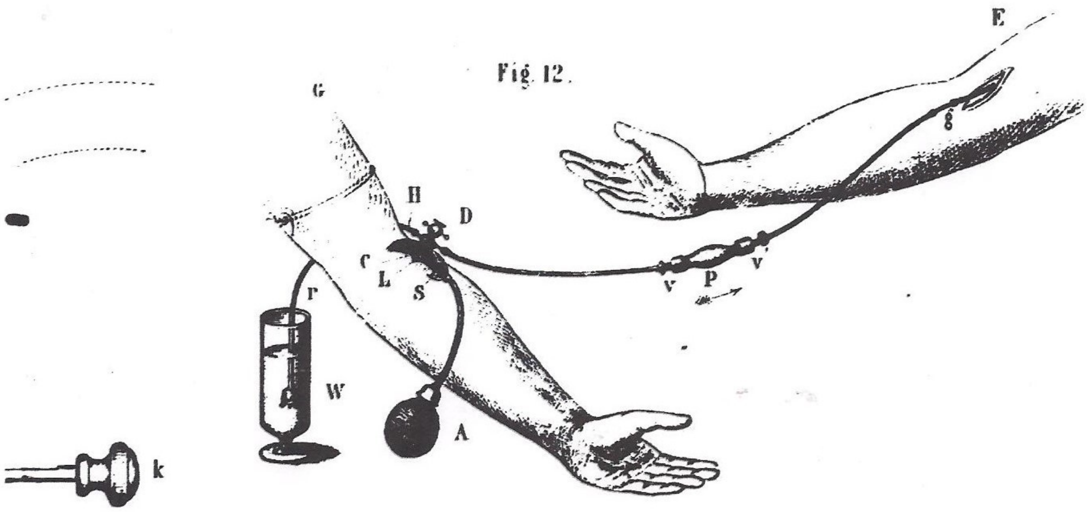
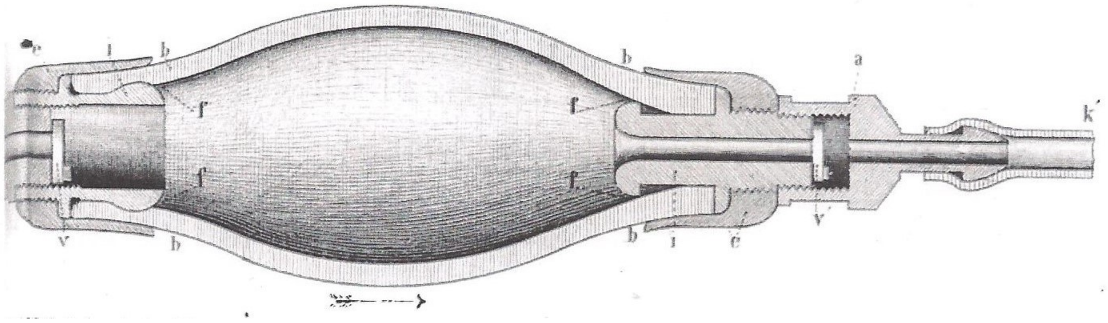


Fig. 15.



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5. W. Braune, Ein Beitrag zur Technik der Transfusion. [A contribution to the technology of transfusion] Langenbeck's Archiv. 1865. S. 648.
6. Eulenburg und Landois, Die Transfusion des Blutes. Abdruck aus Ider Berl. klin. Wochenschrift 1865.
7. Uterhart, Berliner klinische Wochenschrift 1870.
8. Billroth, Ueber einige chirurg. Zeit- und Tagesfragen. Wiener med. Wochenschrift 1875.

9. 1. c. und in Schmidt's Jahrb. 1863. Bd. 118. S. 316. Es soll hierbei vom Nadelapparat, den Demme bei seiner Spritze verwendet hat, ganz abgesehen werden. [The needle device that Demme used for his syringe should not be ignored here]
10. 1. c. S. 63.
11. 1. c. Seite 651.
12. Mosler, Ueber Transfusion defibrinirten Blutes bei Leukämie und Anämie. Berlin 1867.
13. v. Langenbeck's Archiv. Bd. VI. S. 648 ff.
14. Neudörfer, Handbuch, Anhang. S. 144.
15. Die Transfusion des Blutes in physiol. und medic. Beziehung. Heidelberg 1869. S. 123.
16. Gesellius, I. c. S. 16, 17 u. 97.
17. Der hier abgebildete Transfusionsapparat von Leiter ist eine Pumpe aus Hartgummi, die nach Belieben saugt und drückt, und ist dem Kautschukgebläse vorzuziehen; ich habe mit diesem Apparat 6 Transfusionen ausgeführt und kann demselben nur Gutes nachsagen. [The Leiter transfusion apparatus shown here is a pump made of hard rubber, which sucks and pushes at will, and is preferable to the rubber blower; I have carried out 6 transfusions with this device and can only say good things about it.]
18. I. c. S. 84.
19. Comptes rendus 1874. No. 18. 4. Mai. p. 1268.
20. Gazette hebdom. 1874. Nr. 9 und Centralblatt für Chirurgie 1974. Nr. 18.
21. Morgagni 1874. Februar S. 119 und 131 und Centralblatt für Chirurgie Nr. 5, 1974 S. 67; ein Excerpt von Menzel, welches hier benutzt wird.
22. Comptes rendus 1974. pag. 1266.
23. In the obstetrical Journal of Great Britain and Ireland. London 1874. T. I. pag. 297 schreibt Aveling die Erfindung eines directen Transfusor für Menschenblut Mr. Scott zu, welcher schon 1826 die Versuche mit demselben angestellt hat, und er gibt S. 309 eine Zeichnung von diesem Apparate, bestehend aus einer Kautschukpumpe, die an beiden Seiten Kautschukröhren und Canülen trägt für den Blutempfänger und Spender; durch Druck der Pumpe wird das Blut bewegt. [Aveling attributes the invention of a direct transfuser for human blood to Mr. Scott, who had already carried out experiments with it in 1826, and he gives a drawing of this apparatus on p. 309, consisting of a rubber pump, which carries rubber tubes and cannulas on both sides the blood recipient and donor; The pressure from the pump moves the blood.]
24. Die Glasröhre habe ich als überflüssig weggelassen. [I left out the glass tube as it was unnecessary]
25. Man sollte es kaum glauben, mit welchen Schwierigkeiten die Herbeischaffung von Schafen zu Transfusionszwecken verbunden ist. In der Stadt werden keine Schafe gehalten, die Fleischhauer haben ihre Stallungen nicht selten ½-1 Meile ausserhalb der Stadt, von dort mussten die Schafe hereingebracht werden, und weil in der Stadt nicht geschlachtet werden soll, musste das Thier wieder dem Fleischhauer noch lebend zurückgestellt werden, und es bedurfte neben der Zahlung noch guter Worte und Protection, um Schafe für den Fall des Bedarfes zu haben. Wenn ich das Schaf jedesmal hätte behalten können, dann wäre es allerdings leicht gewesen, jederzeit ein Schaf zu bekommen. [It would be hard to believe the difficulties involved in obtaining sheep for transfusion purposes. No sheep are kept in the city; the butchers often have their stables ½ to 1 mile outside the city. The sheep had to be brought in from there, and because there is no slaughter in the city, the animal had to be returned to the butcher alive and in addition to the payment, good words and protection was needed in order to have sheep in case of need. If I had been able to keep the sheep every time, it would have been easy to get a sheep at any time.]
26. Seite 71.
27. 1. c. Seite 12.
28. Gazette hebdom. 1874 vom 14. Juli und Centralblatt für Chirurgie, 1874. Nr. 21.
29. Berliner klin. Wochenschrift 1874. Nr. 4.
30. Compt. rendus 1874. pag. 1268.
31. The Obstetrical Journal 1874. pag. 309.

32. Dr. Roussel hat seinem Transfusor hermetique noch einen Apparat beigegeben, welcher für Thierbluttransfusionen bestimmt ist; dieser besteht aus einer gewöhnlichen Canüle für die Thiercarotis, welche durch einen Hahn absperrbar ist, und aus einer Olive mit doppelter Bohrung, bestimmt, um vor Beginn der Transfusion Wasser aus dem Schlauche in die Pumpe zu führen. Ich habe mich nicht veranlasst gefunden, Gebrauch von diesem Apparat zu machen. [Dr. Roussel added a device to his Transfusor hermetic intended for animal blood transfusions; this consists of an ordinary cannula for the animal carotid, which can be shut off by a stopcock, and of an olive with a double bore, intended to lead water from the tube into the pump before the start of the transfusion. I have not felt compelled to make use of this device.]
33. Compt. rend. 1858. pag. 158.