TRANSFUSION
Handbuch der chirurgischen technik bei operationen und verbänden

BY: A.R. MOSETIG-MOORHOF

A TRANSLATION BY PHIL LEAROYD

The 'transfusion' section (pages 233-248) within the ''Manual of Surgical Technique for Operations and Dressings' by Albert Ritter von Mosetig-Moorhof (1838-1907), published in Leipzig (by Toeplitz & Deuticke) in 1889, can be read or downloaded from the following site:

https://books.google.co.uk/books?id=yzQXES51ItQC&printsec=frontcover&source=gbs_ViewAPI&redir_esc=y#v=onepage&q&f=false

The author prefers the general term 'blood importation' which he differentiates from 'blood transfusion' which he states should be used to describe when blood is brought directly into the circulation, compared with 'blood infusion', which he states is when blood is infused into the lymphatic spaces, or the term 'venous infusion' when a fluid other than blood is infused directly into the circulation. This somewhat overly complicated descriptive approach, which includes the unnecessary occasional use of Latin surgical terminology, is used throughout the 'transfusion section', which I found distracting and occasionally confusing

The author considers indirect transfusion to only be performed using defibrinated human blood, but also discusses the advantages and disadvantages of both whole blood and defibrinated blood (i.e. the possibility of coagulation of whole blood prior to infusion and the problems associated with activation of the 'fibrin ferment' with using defibrinated blood). Because of these difficulties he concludes this section by stating that "blood transfusion cannot be regarded as a harmless operation even if carried out correctly and therefore should only be used as a last resort in cases of extreme danger to life."

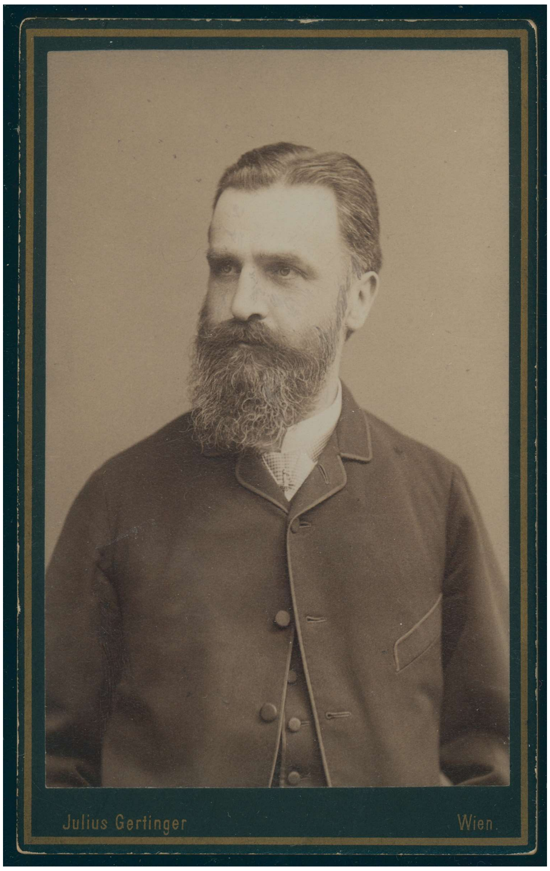
The practicalities of indirect blood transfusion using defibrinated blood are discussed, noting that it requires three people to perform it correctly, i.e. a separate surgeon for both the donor and recipient and an assistant to perform the defibrination and filtration of the donor blood. Even though he quotes the physiological research work relating to showing that coagulation is slower in the cold, he states that 'most surgeons' prefer to warm the donor blood rather than cool it!

There is then a description of the use of different blood 'infusors' used for indirect blood transfusion, with an illustration of three of them, together with a description of Roussel's device for direct transfusion. The content of this section is somewhat inconsistent in that having noted the problems associated with air, valves, metal, rubber tubing, etc., in relation to causing the donor blood to clot; this is not commented on when describing the different blood devices.

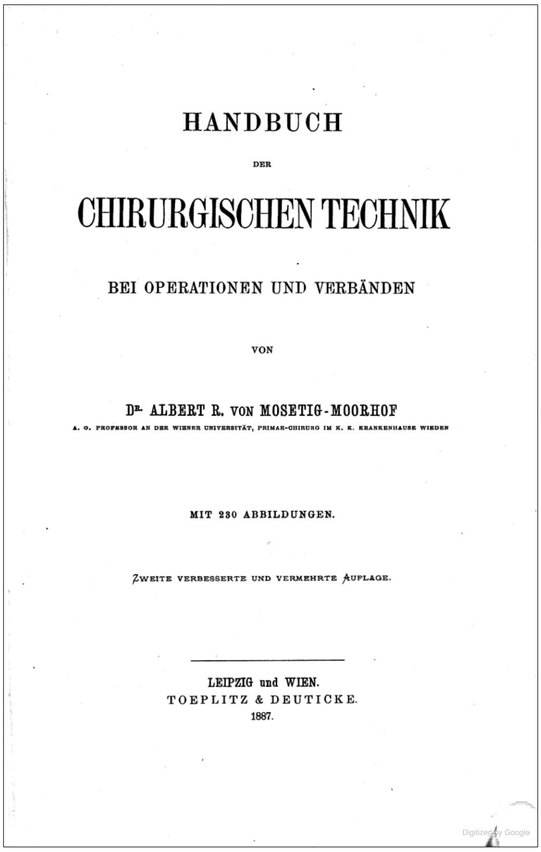
Dr. Mosetig-Moorhof also somewhat confusingly includes a section where he describes using animal blood for transfusion to humans only to conclude it by stating that this procedure has been "consigned to deserved oblivion", together with another section on 'blood infusion', where he describes the procedure for infusing blood into the peritoneal cavity, which he concludes by stating that the procedure is 'not effective'!

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

Although I have taken great care in accurately identifying the original text and producing a true representative translation of the author’s original wording I cannot guarantee that this work does not contain ‘translational errors’ and the reader is recommended to check specific details against the original text. I have maintained the general layout of the text including the author’s use of bold lettering and italics. The three drawings of indirect transfusion devices have been repositioned within the translation. The section does not include references.



Albert Ritter von Mosetig-Moorhof (1838-1907)
(image credit - dcmny.org)



HANDBUCH

DER

CHIRURGISCHEN TECHNIK

BEI OPERATIONEN UND VERBÄNDEN

VON

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MIT 230 ABBILDUNGEN.

ZWEITE VERBESSERTE UND VERMEHRTE AUFLAGE.

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Blood importation. The importation of fresh living blood into the organism can serve a twofold purpose: *a*) one wants either to offer a rapid replacement for what has been lost in large numbers, or *b*) to strive for an improvement of the blood that is sufficiently available but has become unsuitable for the maintenance of the vital functions. Acute **anaemia** arising from profuse haemorrhages, as a result of accidental or artificially induced injuries, from metrorrhagia during childbirth and in the puerperium, or gastro-enterorrhagia in consequence of ulcerative processes, belong to the first class of indications, which are in the first place a question of rapid replacement; indeed, *Hayem* et al. assert that in the case of internal bleeding which eludes direct stoppage, the introduction of blood even has haemostatic effects. **Mass destruction of blood cells** by exposure to carbon dioxide, illuminating gas and other irrespirable gases, by widespread burns, etc., belong to the group of the second indication. Whether septemic blood can be improved is still an open question; likewise, the advice made by Hüter: to conjure up the imminent death of fever by importing fresh blood and thus to develop antipyretic effects, has not yet become ready for judgment. For the group of the first indication it is a matter of pure importation of blood, in the second it is also a matter of a preliminary or simultaneous proportional emptying of the blood that has become unfit for functioning. The introduction of blood can be staged directly, i.e., the blood is brought directly into the circulatory system, it is called transfusion, or it is carried out indirectly, i.e., by means of absorption, i.e. through the mediation of the lymphatic system, it is then called **blood infusion**. Finally, instead of blood, other fluids can be introduced directly into the circulatory system, which is then called **venous infusion**, because such importation is accomplished by means of blood vessels.

a) Transfusion.

Transfusion is synonymous with transferring blood from one individual into the vessels of another. One speaks of a blood donor and a blood recipient. The latter is always a human being, the former can be either a human being or an animal; for the time being, we want to focus exclusively with human-to-human transfusions. It is possible to introduce whole blood, or choose blood free of fibrin, i.e. defibrinated, immediately before importation. In the first case the transfusion is called a **direct** one, in the second an **indirect** one; direct, because the blood is transferred directly from the donor's vessel to that of the recipient; indirect, because the blood must first be taken from the donor, then defibrinated and filtered before it is introduced into the recipient's bloodstream. There has been much debate about the greater value of one method or the other. There is no question that whole living blood must serve as a substitute much more effectually than defibrinated blood; however, the claim that defibrinated blood is absolutely ineffective and even harmful seems somewhat exaggerated. *Gesellius* claims, for example, that every blood cell outside the living organism that has given up its fibrin content has died; that completely defibrinated blood for transfusion is not only useless, but even harmful. *Moncoq* says flatly: "Le sang défibriné n'est plus du sang." On the other hand, extremely precise experiments, which *Maydl* and *Siegel* have recently carried out, have shown that the red blood cells of defibrinated blood in the foreign individual are preserved for a long time, and at any rate continue to function; that they therefore do not act as harmful ballast, as foreign bodies are excreted as quickly as possible, but that their material, even after decay has occurred, is used by the organism for the formation of new blood cells. But even if from a physiological point of view whole blood would be better suited to the purpose, from a practical point of view the question arises as to which of the two methods is safer. The main danger in this regard is probably the possibility of blood clotting. Even without access to air, whole blood coagulates quickly when it is out of contact with the living vessel walls and into contact with foreign bodies, the transfusion devices; indeed, *Afanasyev* claims that in whole blood, even before larger visible coagula are formed, there are already multiple dot-shaped clots, visible only when magnified, the centres of which are released by *Hayem's* hematoblasts. In the case of the transfer of whole blood, there is therefore a danger of introducing coagula into the bloodstream of the recipient, which can act as emboli. Although defibrinated and filtered blood does not bring with it this danger, another, no less serious one comes into consideration. As is well known, *Schmidt* has proved that in the blood released from a vein, a ferment is formed from the rapid decay of the white blood cells, which, in contact with living blood, rapidly stimulates the fibrin dissolved in it to coagulate. It is therefore also called fibrin-ferment. Now, however, defibrinated blood contains such a ferment; if, therefore, defibrinated blood is introduced into a living bloodstream, it can, when it comes into contact with circulating blood there, cause the latter to coagulate to a corresponding extent. But that's not all: *Köhler* demonstrated that the fibrin ferment has a direct toxic effect on the red blood cells, causing them to be destroyed.

Summing up what has just been said, we find that the danger of direct transfer lies in the possible simultaneous importation of clots; in the indirect case there is subsequent coagulation of the blood within the vessels and in a direct destruction of the blood cells by the fibrin ferment. It is therefore clear that both methods have their, at least theoretical, concerns that consequently transfusion must never be regarded as a harmless operation, even if it is carried out extremely correctly, and therefore it should only be used as a last resort in cases of extreme danger to life. A second danger during transfusion is the introduction of air, which could cause the sudden death of the recipient, but this danger can be safely avoided by the precision of the technology. The cardinal points around which the various methods of transfusion, as well as the mechanism and construction of the various transfusion devices revolve, relate chiefly to the hindrance of coagulation, or the concomitant introduction of blood clots, and to the prevention of air ingress. Although *Oré* and others maintain that artificial heat promotes the coagulation of the blood, while cold prevents it, most surgeons nowadays differ from this view, so that it is fairly common practice to artificially heat all devices with which the blood comes into contact before or during the transfer to normal blood temperature, or even a little higher, up to 39 and 40 degrees centigrade, and the cooling down over time should be very carefully prevented. The tubes through which the blood has to flow should have smooth walls, because rough walls could produce coagulation; for the same reason, metal should be avoided as much as possible. Glass and rubber deserve preference. The use of taps, flaps, etc., in the transfusors are to be avoided and the length of the transfer pipes is to be reduced as far as possible. The transfusion itself must be neither too rapid nor too slow, not with interruptions, but continuously. Finally, the compressive force which drives the blood into its new channels should be just sufficient to prevent a possible stagnation of the imports. The amount of blood to be transfused depends more or less on the indications available, but in general there cannot be enough warning against the transfer of large quantities of blood. Since a true transplant sanguinis, i.e. a longer life and functioning of the blood cells in the foreign circulation, is hardly acceptable, it is rather certain that the transfused blood cells die after a relatively short time and their decay products are excreted again by the secretion organs, especially by the kidneys, whereby haemoglobinuria finds its explanation, an excessive supply of blood would be equivalent to an overload of the blood with products of decay and can therefore cause harm to the organism. The permanent replacement of the lost blood is provided by the organism itself. The principal factors of the transfusion effect are: the temporary restitution of the greatly reduced vascular fullness, which has an inhibiting effect on the activity of the heart and consequently on respiration, and a temporary increase in the exchange of gas, which is greatly reduced as a consequence of the lack of blood cells. However, even small amounts of blood are sufficient for this: 300 grams should be the maximum for a single transfusion, 70 the minimum for an adult human. 100 to 200 is the most commonly used quantity. If the transfusion is used for blood poisoning or burns, it is customary to drain an adequate quantity of the blood that has become unusable before importation, and then the flower import is called **transfusio depletoria**. What is meant by **auto-transfusion** and how to use it has already been mentioned.* It goes without saying that it can only be used for the temporary relief of acute anaemia. If it can be used for this purpose, it should always be done and transfusion should only be used when auto-transfusion is no longer sufficient.

Indirect transfusion. As a rule, only venous blood is used for this purpose; if in one case *Gesellius* used blood obtained by cupping, that is, mixed blood according to the quantity, this can only be regarded as a rare exception. The venous blood is taken from the blood donor, who must of course be a completely healthy individual with no diathesis, by bloodletting. The quantity of what is taken must slightly exceed the quantity of what is to be transfused, since a part is lost through defibrination, and the rest cannot be used to the last drop because of the danger of possible air ingress. An increase of 30 to 50 grams is completely sufficient. As it is very desirable that the blood should pass from the one organism to the second as soon as possible, it is almost essential that two surgeons and an assistant should take part in the operation at the same time: one deals with the blood donor, the second with the recipient, the third with the defibrination and filtration of the blood. The donor's arm vein must be opened enough for the blood to flow quickly and in full stream; it is carefully collected in an absolutely pure glass or porcelain vessel, which is heated to 38 degrees. It is best to choose a measuring glass whose scale allows a precise determination of the amount of blood taken in each case. The bain-marie is recommended for heating the vessel, because it is the only way to achieve a constant temperature. Immediately after the bloodletting is interrupted, the defibrination of the blood begins by whisking or beating; the instruments used for this purpose, rod or whisk, are made of glass or porcelain, and not of metal. Ribbed or coiled glass rods are preferable to smooth-walled ones. The beating continues continuously and rapidly for a few minutes. Gradually, coagulation is formed, initially around the rod, and the blood takes on a lighter colour, as a result of the entry of oxygen from the atmospheric air. After about 3 to 5 minutes, the defibrination is complete. Now the blood must be freed from the flakes, it must be filtered. To collect the filtrate, a second vessel is required, also made of glass or porcelain, which is also heated to 38 degrees in a water bath. A white silk cloth or a piece of pure canvas serves as a filtrum. Only that quantity of blood which passed freely through the filter may be used; it is not permissible to squeeze out the residue left in the filtrum. Pouring the coagulum into the filter is avoided by slowly pouring the beaten blood from one vessel through the filter into a second. In the process, the fibrous material sinks to the ground in accordance with its greater gravity and remains there. Fresh coagulation during pouring does not occur if the blood has been beaten properly previously. During these preparations, the recipient's vein is prepared to receive the blood filtrate, i.e. it is exposed, opened and a cannula is inserted in a centripetal direction. In most cases, a vein in the crook of the arm is chosen for this purpose. In the case of acute anaemia, the veins are difficult to see, so it is necessary to try to bring them as far into view as possible. For this purpose, hang the arm of the recipient down vertically at the edge of the bed for some time and then apply a constriction bandage to the upper arm, above the crook of the elbow, in the manner described for bloodletting. If the vein is visible, or even bristling, it is easy to expose; if the anaemia is very severe, and the network of veins remains invisible, the anatomical course must accordingly be followed to find the vein.

The exposure of the vein consists in the cutting of the integument and the isolation of the vessel. The former can be carefully cut through by hand, or a fold can be raised in the case of a flabby thin cover and separated by means of a puncture. It is advisable to make the skin incision in a length of about 1 centimetre at a slight angle to the course of the vessel, especially if a search is to be carried out first. When the skin is cut and the vein is exposed, the edges of the skin are removed, if necessary with small pointed hooks, and the vein is isolated by means of tweezers and scissors, and with the aid of a hollow probe; a delicate approach is strongly recommended. Two silk threads are now drawn around the vessel, which is isolated over a distance of about ½ centimetre, either by means of a pair of tweezers, which are passed together transversely under the vein and into which the threads are then pinched and pulled forward, or by means of an ear probe, or perhaps most appropriately by means of an eared blunt vascular needle. The two threads are placed parallel to each other, and as far apart as the isolated part of the vessel permits; both have only temporary residence. The central thread is used to fix the cannula to be inserted, the peripheral thread to close the vein for the duration of the transfusion. The cannula is either made of metal, or better still of glass, or hard rubber and, if made of metal, often has a blunt or a pointed guide rod; in the latter case, the whole forms a trocar. If one makes use of one of these, it is pierced directly into the vein and, with the covered spine withdrawn, push it a distance into the clearing of the vein, according to the direction of its course. This type of insertion is not recommended, as it can easily happen that the thin-walled vein, which is often only slightly filled, is pierced twice and then the cannula is inserted into the perivascular cell tissue outside the venous opening. It is always more careful to open the vessel by means of scissors by cutting its front wall, either lengthwise, transversely, obliquely or in the form of a small V-shaped flap. Before this act, it is advisable to lift the vein a little from the base by means of the inserted threads and thereby tension it. The cannula is then inserted through the made incision; but in order that their sharp edges do not get caught, the blunt, well-rounded guide rod is desired. The inserted tube, in the clearing of which the guide rod or the covered spine is left for the time being, is fixed into the vein by means of the upper thread. A knot of the thread is neither necessary nor advisable for this purpose, since it is removed after the cannula has been removed after the transfusion; you simply cross the thread around the vein and let an assistant tighten the horizontally placed ends with a loop or a simple bow. The same happens with the peripherally inserted thread, which needs to be tightened even less, since it does not have to fix a cannula, but only to close the thin vein.

For the introduction of the blood filtrate, partly syringes, partly own apparatus are used - **transfusors** = both are also to be warmed in a water bath before use. The transfusion syringes are either made entirely of glass or they have metal caps, better are the ones mounted with hard rubber. *Martin, Uterhart, Eulenburg, Landois* and others have specified such syringes. If it is used, it is filled with the blood filtrate in the usual way by pulling on the plunger, and then, by turning it tip upwards all the air is carefully squeezed out. Now the guide rod is pulled out of the integrated cannula, some blood is allowed to flow out of the vein retrospectively, so that all the air is expelled from the cannula (in the case of transfusio depletoria, of course, the corresponding amount of blood would have to be drained), the syringe is possibly inserted with the use of a rubber tube, loosen the compression bandage and slowly push the contents of the syringe centripetally into the vein by using plunger pressure. How often you have to repeat this procedure will depend on the capacity of the syringe. During each refill, the outlet of the cannula must be held closed with the finger. The usual transfusion syringes rarely hold more than 20 to 30 grams, because they become less manageable when they are larger, which means that when they are used repeated interruptions and discontinuity of the operation are unavoidable. This circumstance probably initially stimulated the desire to replace the syringe with devices which would enable a continuous, uniform transfer and ensure independence from the respective stamp printing. It was in 1870 that *Bellina* invented a transfusor that was awarded a prize by the Paris Academy.

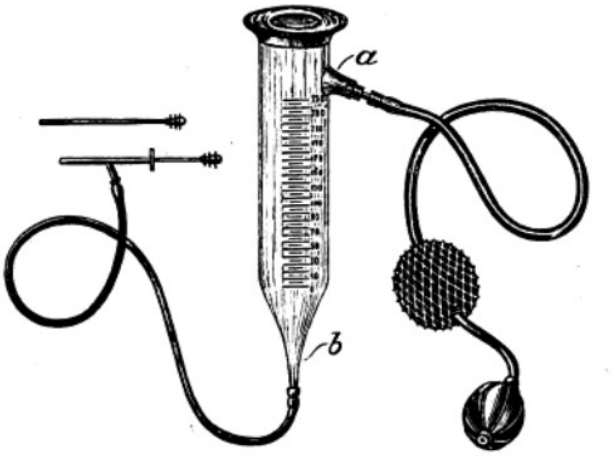

Fig. 60 – Bellina's transfusor; a) Inlet pipe, b) Outlet pipe.

The transfusor is very simple, allows a continuous transfer, enables the force with which the blood is introduced to be regulated, is very easy to clean and keep pure, a circumstance the importance of which need not be emphasized, and dispenses with all valves and other complicated equipment. Fig. 60 illustrates the apparatus. The glass vessel, which is left in a warm water bath until the filtration is complete, is filled with the filtered blood by means of a glass pouring pipe *a* and the funnel spout pipe, while the index finger closes the outlet drain *b*. Once the transfusor, which was held horizontally until now, is filled, the pouring tube is temporarily closed with a rubber stopper and the vessel is placed on the cover plate, with the end of the drain standing vertically upwards. A rubber tube of appropriate width is now connected to it, a flannel-lined bag that is open at the side is placed over the glass vessel (to prevent the vessel and its contents from cooling down during the transfusion); the vessel is turned over in such a way that the drain opening looks downwards, a little amount of blood is allowed to flow out of the rubber tube and then, while clamping it a little higher up with the fingers the end is connected laterally with the cannula after the air has been removed from the branch tube by the retrograde outflow of a few drops of blood. The guide rod is not completely removed, but only pulled up to behind the junction opening of the cannula branch. But in order to hit this spot exactly, i.e. not to pull the rod backwards too far or too little, the rear surface of the cannula plate has a spiral spring and the rod has a ring-shaped groove. When the rod is now pulled out of the cannula until the annular groove reaches the surface of the cannula, the spring intervenes, braces itself against the groove and by the sudden resistance draws the surgeon's attention to the fact that the end of the rod has cleared the mouth of the cannula branch. This sign is observed with the retraction of the rod and a few drops of blood immediately appear at the outlet of the branch tube. Now the rubber tube of the supply line is attached to it, the finger clamp is released and the flow begins. Now remove the rubber plug from the pouring tube, set the transfusor as high as the short guide tube allows and the compressive force of the liquid column lets it flow in. Since, however, a longer length of the guide tube is understandably to be avoided, and on the other hand the intravenous pressure could possibly become equal to that of the fluid column, which would delay or make further inflow impossible, *Bellina* has added a *Richardsonian* double blower to his transfusor, which can be attached to the upper pouring tube so that the air space above the liquid column can be compressed as desired. It is now up to the surgeon to increase and regulate the fluid pressure as required. *Carmalt Jones* recently devised a completely analogue transfusor. *W. Walter* modified *Bellina's* transfusor to the extent that he had an apparatus made which is completely similar to a wound rigator. It consists of a cup-shaped glass vessel, which ends into a drain tip at the bottom, to which a rubber tube is attached. The vessel has no wall at the top, is open, and therefore does not allow the liquid pressure to be regulated, except by raising or lowering the vessel. The cup, like *Bellina's* glass case, is equipped with a scale, which allows the quantity of blood supplied to be read in each case. With these transfusors, it is absolutely impossible for air to enter the bloodstream during infusion; this could only happen if the contents of the vessel have completely drained away, i.e. subsequently. To prevent this, the inflow should be stopped before the last remnant of the blood has penetrated the guide tube. A clamping of the tube with two fingers together with a lowering of the vessel is sufficient for this purpose. *Collin* has constructed a rather ingenious transfusor, which works by suction and pressure; the motor to both is given by a syringe (Fig. 61). What is interesting to note is that the otherwise indispensable flaps are replaced by a hollow aluminium ball, which floats in the interior of the housing section *a* and which, by virtue of its physical properties of being lighter than blood and heavier than air, makes any air entry impossible. The upper bowl is used to receive the blood. The syringe content is 10 grams. Pulling back the plunger aspirates blood into the syringe chamber, pushing it forward drives the blood through the rubber tube to the recipient. The aluminium ball – called flotteur – (floater) takes over the flap effect through its respective play and, as emphasized, prevents any air entry with apodictic certainty. Nevertheless, *Collin's* apparatus has several disadvantages in comparison with *Bellina's*. Simplicity. It cannot be denied, just as the security of action cannot be denied, but it shares the disadvantages of syringes in general and has too much metal.

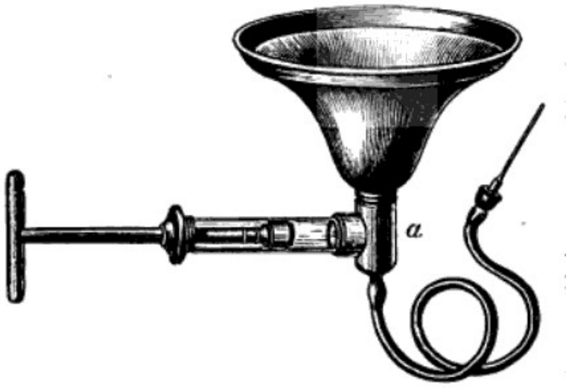

Fig. 61 – Collin's transfusor.

Once the transfusion is complete, the sutures that secured the inflow cannula and peripherally closed the vein are removed and those are pulled out of the vein. A finger placed on the skin wound temporarily blocks the venous wound; the blood recipient's arm, which until now had been fixed horizontally on a firm surface in a prone position, is elevated, the area around the wound, which may have been soiled, is cleaned, and a bandage applied similar to that after bloodletting; in the case of a slightly larger skin wound, it can be closed with a few catgut sutures. A double binding of the vein by means of the threads is unnecessary, can be harmful and is therefore reprehensible.

The method of transfusion described so far involved the introduction of defibrinated filtered blood into a vein; blood prepared in this way can also be transfused into an artery, and the transfusion is then called an arterial one. *Hüter* described it first. The direction in which the blood is to be introduced is naturally centrifugal, i.e. identical with the direction of the circulation. *Hüter* ascribes the following advantages to this method: the imported blood must pass through the capillary network and is freed from all foreign harmful admixtures in this natural filter. Emboli in the central organs are therefore excluded, but possible emboli in the smaller arteries of the extremities are harmless; air ingress becomes safe because the air bubbles are absorbed in the capillaries; the flow into the venous pathway occurs gradually, therefore a sudden overfilling of the right heart is unthinkable; finally, venous thrombosis is ruled out. The technique is as follows: a smaller extremity artery is chosen for the transfusion: radialis or tibialis postica, expose it, isolate it to a length of a few centimetres and pass 4 threads underneath it transversely. The central thread is used to immediately tie off the vascular tube, the middle thread secures the cannula, which is inserted into the lumen of the artery through a wall incision, while the peripheral thread temporarily shuts off the artery during the tying process to prevent retrograde bleeding. At the beginning of the transfusion, the peripheral thread is loosened again, but left in place in order to completely and permanently stop the peripheral artery end after the operation is completed. The piece of artery located between the two ligatures, including the cannula and middle threads, is simply excised, and the wound is closed by a suture. The difficulty of carrying out the transfusion lies in the resistance of the capillary networks; the pressure under which the blood has to be driven in is a significant one and can only be achieved by stamp pressure. This method is therefore abandoned; it could only be used in one case: to revive frozen limbs. After experiments on animals, *Landois* recommended centripetal arterial transfusion instead of centrifugal, i.e., the introduction against the blood flow, in order to quickly restore the extinguishing vascular pressure by backing up and to stimulate the activity of the heart; yet, in order to increase that, a larger vein should be compressed at the same time. This method has not yet been used in practice.

Direct transfusion. As already emphasized, this method is intended to transfer whole blood from one organism to another. It has already been mentioned that the main danger lies in the introduction of clots, which can form during the passage from one vessel to another. In order to prevent this, it is necessary to carefully prevent all those moments that could give rise to blood clotting. On the one hand, the entrance of atmospheric air to the overflowing blood must be prevented; on the other hand, the conduction pathways must be taken into account. The use of metals, the application of valves, roughness of the tubes, cooling of the blood, etc. are factors that promote coagulation and should therefore be avoided as much as possible. The simplest instrument would probably be a smooth-walled, not too long, heated rubber tube with two glass cannulas, one of which is integrated into the bloodstream of the donor, the other into that of the recipient, after careful removal of the air in accordance with the direction of flow. However, this simplest, and therefore most appropriate of all devices can only be used if the blood is to be transferred from an artery to a vein, because the pulse force could serve as the driving force. If, however, as is usually the case, direct transfusion from vein to vein is to be performed, a motor must be switched onto the conduction tube, which, acting as a suction and pressure pump, enables and makes the transfer possible. In the diversity of the motor lies the difference of the many devices devised for direct transfusion. As far as I know, *Roussel* first produced a direct transfusor. The apparatus bears a resemblance to those well-known instruments for self-enema, which essentially consist of a rubber tube, which has a rubber ball in its middle, which acts as a suction and pressure pump. One end of the tube is attached to the cannula that was previously integrated into the recipient's vein, the other end supports a cupping-like glass container, constructed as follows: it has the shape of a bell, the base of which is rounded and somewhat wavy, because it is intended to be hermetically attached to the elbow bend of the blood donor. On the edge of the base are two diametrically opposed small marks; they are intended to be placed according to the course of the vessel (blood-donating vein), i.e. they indicate exactly the direction in which the bell is to be adjusted. A small rubber balloon mediates the air dilution in the bell chamber and ensures the cupping-like adhesion of the housing. In the middle of the inner rim of the housing is a round glass cylinder, the base of which corresponds exactly to the level of the bell. In the centre of the cylinder is a vertical metal rod which breaks through the roof of the housing and ends with a flat button, while its lower end bears a sharpened pointed lancet, or rather a flute. Two rubber pipes open into the cylinder chamber from above; one is the end of the transfer tube, the other is shorter and has a weighting ring. The rubber balloon of the bell chamber is first pressed together and at the same time the bell is placed in the plica cubiti in such a way that the edge marks correspond exactly to the course of the selected donor vein; the balloon is then released, it expands, dilutes the air in the bell chamber and fixes the bell in the given position. The edge of the cylinder space also applies exactly to the skin, because it is level with the rim of the bell, and compresses the vein in two places, which runs in the sense of a diameter, whereby its intermediate part becomes somewhat more protruding, because it is more full of blood. Now the whole apparatus is first filled with a warm ½ per cent solution of carbonate soda; to do this, dip the shorter, weighted rubber tube into the solution and begin to compress the rubber balloon in the course of the flow pipe on a regular basis. In this way the air in the cylinder chamber is gradually diluted, whereby the warm sodium bicarbonate solution flows through one tube into the cylinder chamber and from there into the flow tube, finally to the outside. If, with continued pumping, sodium bicarbonate solution flows out at the end of the outlet, all air is emptied from the apparatus. Now close the inflow tube, place the metal rod so that the fringe corresponds to the direction of the vein and press firmly on its outer buttoned end, whereby the flute penetrates the vein. If the rod is immediately withdrawn, the flute is removed from the wounded vein; which is gaping, the bloodletting is finished. Now the balloon is pressed slowly and gradually, the pump expels the sodium bicarbonate water, but at the same time blood penetrates into the cylinder space. In this way, the water is gradually removed and blood is put in its place. If pure blood is revealed, the end of the drain pipe is connected to the cannula, which has been emptied by the return of blood, and the blood is pumped directly from the donor's vein into that of the recipient. Each single pressure of the balloon empties about 5 grams of liquid. It is therefore easy to determine the amount of blood transfused in each case. However ingenious the apparatus may be from a technical point of view, it suffers from two essential defects. On the one hand, it is at least possible that the passage of the metal rod does not close completely airtight, and on the other hand, a miss of the vein, or an inadequate opening of it, is not always to be avoided, since the operative act is carried out mechanically and completely eludes the hand and control of the surgeon. The complexity of the device, which makes the accuracy of the construction infinitely more complicated, has also made simplifications desirable, and so the devices of *Aveling, Landois, Schliep* and others came into being, in which no bloodletting is carried out, but a cannula is integrated into the prepared blood donor vein, while the quality of the driving force was retained. A different apparatus, if not in effect, at least in essence, was devised by *Moncoq* at that time. Imagine a glass clysopompe with two drain pipes with flaps to which rubber hoses are attached. A key moves the plunger of the pump, which works sometimes by suction, sometimes by pressure. The latest direct transfusor has been devised by *Dieulafoy* (Fig. 62). It is essentially the same as *Collin's* transfusor (which, by the way, is also supposed to be used for direct transfusion); we find the horizontal pump, we come across the aluminium float that replaces the flaps. Only the bowl is conveniently replaced by a hermetically sealed small glass case, into which the blood is pumped into and expelled out of again in a different direction. This apparatus is also filled with warm sodium soda water before use, thus making it airless. However, the main difference between *Dieulafoy's* transfusion method and the others is that it is not necessary to isolate the vein of the donor or that of the recipient, nor to insert a cannula or do bloodletting. *Dieulafoy* uses two trocars, which he pierces directly into the respective veins according to the direction of the current, i.e. through the skin, subcutaneous pulp and outer vein wall at the same pace. However, this saves the whole procedure of exposure, isolation, thread pulling, splitting and insertion of the cannula and reduces its use to a minimum, to a small stab wound. The giver and receiver certainly gain a great deal from this, because the wounds heal in less than 24 hours, the veins remain intact and, as *Dieulafoy* emphasises, can be used for repeated transfusions. However, one concern arises, that of the safe percutaneous insertion of a pointed trocars into the lumen of a vein may not always succeed so easily, and that in the case of faintly visible veins of quite anaemic subjects, it is at least possible to get with the trocar either past the vein or through the vein into the perivenous cell tissue.

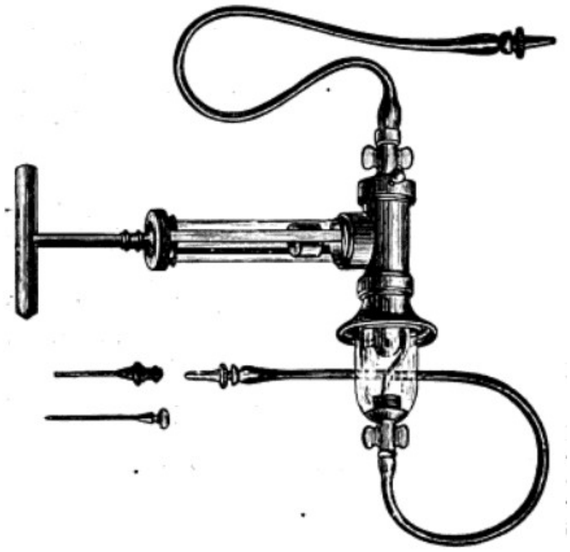

Fig. 62 – Transfusor according to Dieulafoy.

It is worth mentioning that *Küster*, with the help of *Schliep's* transfusor, successfully performed a direct arterial transfusion by transferring arterial blood from the central end of the blood donor's artery to the peripheral end of the recipient's artery. Direct transfusion has the technical advantage over indirect transfusion of greater simplicity and less need for instruments and assistants. On the basis of animal experiments, *Afanasyev* has recommended adding a peptone saline solution should be added to the whole blood to be transfused, in order to prevent the formation of clots, which makes the use of both the direct and indirect transfusion methods permissible, without the need for defibrination in the latter case. When direct transfusors are used, a side tube is added to the apparatus for this purpose, so that blood and peptone saline solution heated to 40 degrees are sucked in at the same time and both are mixed and fed into the recipient's circulation.

Animal blood transfusion. It is quite self-evident that only the blood of animals whose blood cells are not larger than those of humans can be used for transfusion purposes, otherwise their passage through the capillaries would be difficult. So far, only sheep's blood has been used, but dog blood is also said to be usable. *Samson* was the first to recommend the transfer of animal blood, *Gesellius* and *Hasse* in the last decade praised lamb's blood transfusion especially for chronic anaemia caused by internal diseases. Non-defibrinated arterial blood should always be directly transfused into a patient’s vein by the simple insertion of a suitable rubber tube with attachment cannulas. Defibrinated lamb's blood is said to have a toxic effect; nevertheless, *Hiller* claims to have carried out serum transfusions of sheep's blood, mixing the serum with saline solution in a ratio of 1:2, with good success. The enthusiasm with which the animal blood transfusion was initially received was indescribable: tuberculosis was to be greatly improved with it, the transfused would revive, have a new lease of life and revel in undreamt-of well-being, in times of war flocks of sheep were to follow the armies for transfusion purposes for the benefit of the wounded, etc. etc. Soon, however, disillusionment set in. If similar blood is not preserved on different soils, then dissimilar blood cannot survive, the blood of another animal species! The severe, dangerous symptoms which manifested themselves in the recipient after the transfusion soon brought the animal blood transfusion out of fashion and consigned them to deserved oblivion.

b) Blood infusion.

As already emphasized, I want to use the name blood infusion to refer to the transfer of blood not within the bloodstream, but outside of it. The locality where the import takes place can be either the **peritoneal** cavity or the **subcutaneous cellular tissue**. In both cases, the absorption of the infused blood into the organism is mediated by the lymphatic vessels. *Ponza, Voisin, Casse* and others have recommended the incorporation of the blood by means of subcutaneous cellular tissue, using the same technique described in hypodermic injection. *Ziemssen* confirms the fact, which is beyond doubt for him, that any quantity of blood can be supplied to the circulation from the subcutaneous cell tissue thereby achieving a permanent increase in the haemoglobin content together with an increase in the red blood cells capable of functioning. He advocates a frequent repeated supply of small quantities of defibrinated human blood (about 50 cubic centimetres each), especially in cases where it is an improvement in chronic blood diseases. *Ziemssen* gives the following instructions regarding the surgical method: a) Strict adherence to antisepsis with 5 per cent carbolic water and 1 per mille sublimate water; (b) blood is obtained by bloodletting; maintenance of blood temperature, defibrination, filtration, etc.; c) the injection syringe holds exactly 25 cubic centimetres in its glass cylinder; its puncture cannula was drilled quite thickly so that the blood could easily pass through. Before use, boil the hollow needle in carbolic water; d) already during the injection into the subcutaneous cell tissue (usually the thighs are chosen for this purpose, so that 25 cubic centimetres are incorporated into each of them, i.e. 50 in total) the injection should be started immediately with the passing of the injectum by vigorous centripetal effleurage and this type of massage should be continued for 5 minutes after the end of the injection, because this is the only way to ensure the rapid and complete passage of the injected blood into the cleft spaces of the pulp and from there into the lymphatic stream. The infusion of whole or defibrinated blood into the **peritoneal cavity** by *Ponfick* has not proved effective. Although *Hayem* claims that the peritoneal infusion is equivalent to a transfusion carried out very slowly, and *Obalinski* calculated, according to animal experiments, that for every 1 kilogram of animal, 0.5 to 0.7 cubic centimetres of blood are absorbed in one hour, and that without any loss of blood cells; the one death that occurred after such an infusion with peritonitic phenomena is probably sufficient to indicate the danger of such interventions. Finally, *Möller* chose the **intestinal canal** as the locum infusionis. He applied 150 grams of fresh whole pig's blood, heated to 37 degrees, with the addition of 1 per cent chloral hydrate as a clysma. Like the chloral hydrate, *Oppermann's* maintenance salt or peptone saline solution can also prevent the blood to be infused from clotting. *Fubini* has tried inhalations of defibrinated blood, atomizing 20 parts of defibrinated fresh ox blood with 80 parts of 0.75 per cent saline solution by means of an ordinary hand spray. In this mixture, the red blood cells are supposed to remain unchanged for a long time. The inhalations are allegedly well tolerated; this is said to have brought about an improvement in anaemic conditions.

c) Venous infusion.

As a replacement for the lack of blood, two fluids were introduced into the bloodstream according to the method of transfusion: **milk** and **saline solutions**. The infusion of milk brought to blood heat was experimentally tested and recommended by *Muralto* 200 years ago. *Thomas* and *Howe* have recently resumed this method, and have allegedly carried it out in two cases with favourable success. The former introduced freshly taken cow's milk, the latter goat's milk. However, since milk cannot possibly replace blood, it cannot be seen why fat should be brought directly into the bloodstream. Experiments on animals teach that it cannot always be done with impunity. Saline solutions were recommended by *Schwarz* and *Ott*. *Schwarz* recommends a solution of 0.6 per cent with the addition of as many drops of potassium or sodium hydroxide as necessary until the liquid reacts alkaline (1000 distilled water, 6 table salt, 0.05 potassium or sodium hydroxide). The liquid is heated to 38 to 39 degrees Celsius and introduced into a vein, only *Halsted* has introduced it into the radial artery, namely centrally. The technique and precautionary measures against air ingress are the same as those commonly used in indirect blood transfusion, of course, exceptis excipiendis.

The physiological effect of a saline infusion can obviously only consist in increasing the vascular pressure; accordingly, it will therefore only be reported if it has suddenly been reduced so rapidly that there is a risk of cardiac paralysis and if it is impossible to obtain blood quickly enough for transfusion purposes. The value and use of saline infusions in cholera was discussed in Chapter I of this section. In acute anaemia, up to 500 grams have been infused, and in several cases of carbon dioxide poisoning, infusio depletoria has been used with good success. *Maydl* is quite right when he rejects saline infusion in acute anaemia insofar as he decidedly prefers the indirect transfusion and emphasizes that the latter really has a life-saving effect because it supplies still temporarily functioning blood cells to the bloodstream, while the former, because it is dispensable, only provides momentary recovery. However, it is not entirely to be despised, and human blood is not always at hand. Saline infusions carried out with moderation and purpose therefore deserve full consideration as a remedium anceps.

Kronecker recommends a simple saline solution in a ratio of 0.7 to 100 for venous infusion; he completely rejects the addition of 0.1 sodium carbonicum recommended by Szumann for the purpose of alkalizing the liquid, and declares it, according to his animal experiments, to be directly harmful. In order not to cause damage, only 6 to 9 cubic centimetres of fluid per second should flow into the vein in question. *Landerer* recommends adding 3 per cent cane sugar to the saline solution; he further emphasizes the advantages of a combination of blood transfusion with saline infusion by taking 1 part of defibrinated blood with 3 to 4 parts of saline. Smaller quantities of blood are required than with pure transfusion and the dangers of the fibrin ferment are considerably reduced. The results with this combined process are said to be quite excellent.

Of all the above-mentioned types of blood importation and their surrogates, indirect transfusion, i.e., the importation of defibrinated and carefully filtered human blood deserves decided preference. Of course, the blood may only be imported without anaesthesia; neither the donor nor the recipient may be subjected to it, but there is probably nothing to prevent the use of local anaesthesia. The symptoms that can be observed during and soon after a transfusion include: constriction of respiration to the point of dyspnoea, cyanosis, loss of consciousness, severe kidney pain with discharge of bloody urine, vomiting, defecation, chills, fever, urticaria, etc., etc., finally sudden death due to air ingress, embolism, extensive blood clotting, overexpansion of the right heart, or backflow of the superior vena cava blood flow against the oblong medulla.

* 'Auto-transfusion' is mentioned on page 70 when discussing localised loss of blood circulation within parts of the body during an operation and then allowing the blood to circulate back afterwards. - PL