LA TRASFUSIONE DEL SANGUE

BY: Dr ENRICO MORSELLI (1876)

A TRANSLATION OF PAGES 316-351 BY PHIL LEAROYD

The book 'The Transfusion of Blood' by Enrico Morselli was published in 1876 in Torino [by Ermanno Loecher]. A copy of this 603 page book can be viewed or downloaded at:

https://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwid0bP47LjtAhWjQUEAHVIcAGsQFjAAegQIBBAC&url=https%3A%2F%2Fbooks.google.com%2Fbooks%2Fabout%2FLa_trasfusione_del_sangue.html%3Fid%3DfsSCHAAACAAJ&usg=AOvVaw34K7fEHvePNeTOjTl-TuMj

Chapter 4 of the book is titled 'Technology' and contains three sections relating to the transfusion of blood, i.e.

1. Essential Technical Conditions
2. Instruments (pages 316-351 inclusive)
3. Operational Processes for Transfusion

Within the 'Instruments' section of chapter 4 Morcelli provides comments about and illustrations of the different types of blood transfusion instruments that had been developed to perform a blood transfusion. In doing so, the author attempts to provide an honest assessment of the different types of instruments, commenting for example that many of these were only used and generally praised by those who invented or modified them! He identifies that technically there are only two types of blood transfusion methods, direct and indirect. He initially states that direct methods are only viable if arterial donor blood is used, due to the donor-recipient venous pressure differential being otherwise insufficient to ensure an adequate blood flow, which therefore identifies that a human donor cannot be used. He then however goes on to describe instruments used for direct transfusion using venous blood, together with the involvement of 'physiological or artificial' pressure.

He discusses the 'primary importance' of ensuring that 'natural blood' does not clot but still discusses (and recommends) the use of various types of equipment for the indirect transfusion of donor venous blood that must lead to air / surface contact activation of coagulation arguing only that this can be avoided by using the instruments rapidly (whilst also avoiding the transfusion of clots).

As such, Morselli presents the information on instruments in three sections and in doing so also separately considers the importance of knowing the volume of blood that is actually transfused:

1. Instruments for direct transfusion
    a. Physiological pressure instruments
    b. Artificial pressure instruments
2. Instruments for indirect transfusion
    a. Instruments for indirect transfusion using defibrinated blood
    b. Instruments for indirect transfusion using natural blood
3. Determination of the amount of blood transfused

I have translated the ‘Instruments’ section of Chapter 4 of this book from the original Italian 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 a result the reader may find that the English text does not ‘flow’ as well as it could. Whilst some of the words / terms originally used are obviously open to interpretation, I have attempted wherever possible to hopefully maintain the author’s meaning, intent and detail. 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 Italian text.

Whilst I have tried to maintain the original paragraph settings, the positions of the various illustrations may vary from the positions within the original text due to space constraints. The use of italics within the translated text is the author’s own. Morselli uses the word ‘schizzetto’ to describe the types of basic instrument used for the indirect transfusion, which I have translated to mean ‘irrigator’ (i.e. differentiating it from a syringe) as well as the word ‘cauchou’, which I have translated as meaning ‘natural rubber’. There are also two words in the original text that I am unable to accurately translate, which I have included as the original Italian within square brackets in the translated text.

The references to the text within the book are included at the bottom of each page. I have sequentially renumbered these and placed them, as written, at the end of the translation.


LA

TRASFUSIONE DEL SANGUE

DEL

Dott. ENRICO MORSELLI

con 25 incisioni.

ROMA TORINO FIRENZE

ERMANNO LOESCHER

1876.

Title page of La Trasfusione del Sangue (1876)
(Image credit: Wellcome Collection)

Enrico Morselli
(Photo credit: en.wikipedia.org)

ENRICO MORSELLI – BIOGRAPHICAL INFORMATION

Enrico Morselli is best known for his work as a psychiatrist and not for his book on blood transfusion. He was born on the 17th July 1852 in Moderna. His father died in 1855 and as a result was influenced by a great uncle who helped with his early education placing him in a private high school in Moderna. He subsequently studied at the Faculty of Medicine and Surgery at the University of Moderna, where he was taught by the zoologist Giovanni Canestrini and the anatomist Paolo Gaddi. He graduated in July 1874 with a thesis titled 'Blood Transfusion'. It is this thesis which was later published as 'The Transfusion of Blood' by Loescher in 1876, a process which he describes in the preface. Within the book, he provides information relating to the lack of effectiveness of blood transfusion in the treatment of psychiatric patients, already therefore relating it to his career interests. On the 15th August 1874 Morselli was hired as a voluntary assistant at the Asylum Institute of Reggio Emilla. A few months later he obtained a post-graduate post in anthropology at the Institute of Higher Studies in Florence under the guidance of Paolo Mantegazza, the founder of the Italian Society of Anthropology and Ethnology. In February 1877 he married and moved to Macerata where he had been hired as Medical Administrative Director of the Asylum of S. Croce, and in 1880 he became head physician and forensic psychiatrist at the Turin Asylum. In 1881 he founded the Journal of Scientific Philosophy. He taught various disciplines over the years, including psychiatry, forensic psychology, experimental psychology and anthropology and became famous for a number of his publications. During this time however he never returned to blood transfusion and died in Genoa on 13th February 1929.

Additional information regarding Enrico Morselli' life and career can be found at:

https://it.m.wikipedia.org/wiki/Enrico_Morselli
https://web.uniroma1.it/archiviostoriapsicologia/enrico-morselli

CHAPTER 4 – SECTION 2

INSTRUMENTS

If there is an operation in which instruments may have importance, it is this, blood transfusion. And this is easily understood. Maintaining the blood's vital properties and injecting it without any danger, here are the two essential indications to which transfusion instruments should respond perfectly; since if they do not occur, the result of the operation can only be fatal. This consideration has prompted transfusors to multiply and modify the instruments so much that surgery now has a real arsenal for transfusion alone. But do all these instruments have equal value? Do they really respond to a practical need? We deeply doubt it, when we see that each of these instruments is only used and generally praised by those who invented or modified it. However, as of now we are pleased to point out the ingenuity, the profound knowledge of the most subtle laws of mechanical physics, the skill that their inventors have shown in many of these tools; but we would have liked fewer tools and more conformity of ideas, more concordance in practical results – what has absolutely been lacking so far.

In order for blood to be introduced into a vein or an artery, it is advisable to exert a certain pressure on the liquid, when the initial impulse possessed by the blood is not sufficient. On the other hand, we can do without an artificial pressure, when that naturally possessed by the blood can be used without danger or disadvantage. Thus we would have two first sets of instruments: the instruments, through which the blood passes while retaining its impulse, and they are those which are used especially for direct transfusion from vessel to vessel; and the instruments, in which the blood undergoes any pressure that pushes it into the blood vessels. But the transfusion technique has put the industriousness of the transfusors to such torture that they have found a way to use the initial pulse of blood and artificial pressure at once. As for the pressure, whatever it may be, it must be uniform, without jolts, continuous, otherwise there is the risk of introducing the blood in jerks, intermittently, which would cause immense damage. The conditions which a transfusion instrument must meet in order to be perfect, are already sufficiently evident from what we have explained in the previous chapters. We will limit ourselves to these, which are the main ones:

1° Avoid blood clotting (if the blood was not defibrinated);
2° Prevent the entry of air into the vein, which despite the singular safety boasted by some surgeons, is always, as Landois says, one of the most serious accidents of transfusion;
3° Be able to ascertain if the blood coagulates and flows in the tubes and if it is actually introduced into the vein;
4° Calculate as exactly as possible how much is the dose of the blood that is transfused.

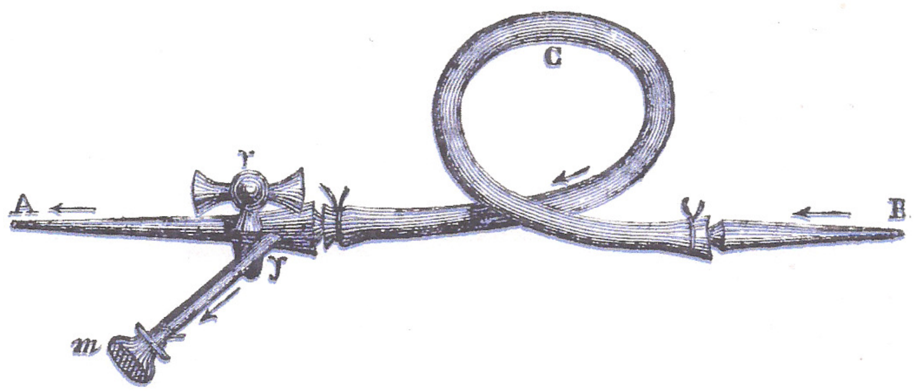
1. Instruments for direct transfusion.

Technically speaking, there are only two transfusion methods: direct and indirect. We would not hesitate a moment only to give every preference to the former, even for transfusion from man to man, if we possessed in the instruments the way to remedy the many drawbacks, which could arise by connecting the artery of a healthy man with the vein of a patient. But the arteriotomy of the first is a serious operation, which will never be justified in any way by the serious condition of the second subject. Therefore, it is unfortunate for us in man to refuse direct arterial transfusion. Is the venous possible? By studying the physiological conditions of vascular pressure, we saw that for the passage from vein to vein, however short the journey may be, the pressure of the vein of the blood giver will hardly be able to overcome the resistance offered by the veins of the transfused, unless the mentioned circumstances of decreased pressure in the latter due to special states of the body (anaemia, chronic weakening). Instruments can meet these needs when they have ways of artificially helping natural blood pressure. For direct transfusion we therefore have two kinds of instruments: 1° those in which the pressure is entirely physiological and the blood does not come into contact with the air; 2° those in which the pressure is wholly or partly artificial, and in which the air cannot come into contact with the blood.

Physiological pressure instruments – The simplest instrument of this kind is a tube which connects the two vessels; the blood enters the tube pushed by cardiac and vascular pressure, runs through it and enters the other bloodstream. This would be the best instrument; and note that in transfusion the more simplicity of an instrument, the more its practical value. The ancient transfusers of the seventeenth-century used tubes, which were rather inconvenient. Imagine that a rigid tube with bent ends served as a communicator; one end was introduced into the animal's artery and the other end into the human vein. The animal (generally a lamb) was fixed with ropes to prevent it from moving; this was indispensable for the stiffness of the tubes, which every slightest motion of the beast could bring out or move the tube within the vein of the patient. Denys, Lower, King, Riva, Manfredi used these instruments. Anyone who wants to have an idea of it has only to consult Manfredi, Mercklin, the *Armamentarium* of Sculteto, and he will be persuaded how primitive the technique was. The tubes were of silver, brass, or bone; but having found it inconvenient to apply the straight and curved metal cannulae, it was decided to replace them with others that were softer and more flexible, made either with a carotid artery (Mayor used a dried horse artery), or with an ox, calf or sheep ureter, or with the tracheae of a hen or a duck, thus being able to transfuse blood with less pain and annoyance (Heistero) (1). Meanwhile, since his time, as we have seen, Libavius described instruments formed of two silver tubes (*tubulos argenteos*), one of which would be inserted into the artery of the healthy, the other into the artery of the patient, and when had they joined together, the communication of the two vessels would have been obtained (2).

But such instruments were very defective and dangerous; nothing was easier than introducing air, and on the other hand we believe that the instrument described to us so well by Libavius had not yet been used by any sensible surgeon. Nor is it credible that all the instruments figured by the authors of the seventeenth century were used, as is that of Folli, who, as we know, neither experimented nor practiced transfusions (3).

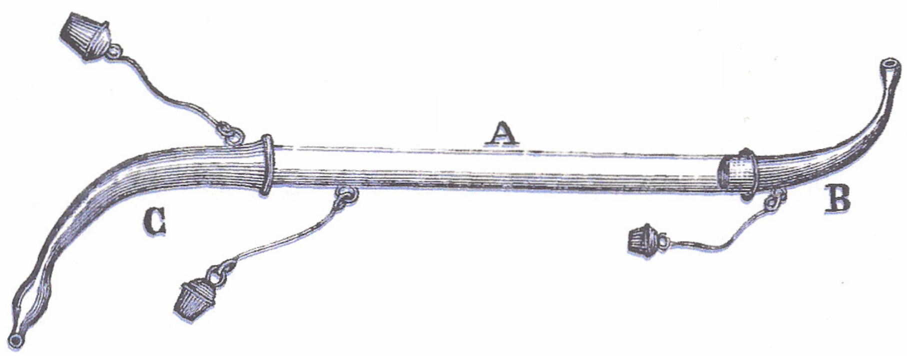
Fig. 2.



The moderns improving the technique have used different instruments. For physiological research, the simplest is a rubber tube, or hemodrometer, terminated by two cannulas, one of which enters the vessel of the individual who gives the blood and the other enters the vessel of the one who receives it. The instrument we used for our experiments was so shaped: it only had a tube from which it was possible to know if clots had formed, and the blood flow could be maintained even if the communication between the two vessels was closed by the tap (Fig. 2).

Analogous are the instruments proposed or used for the direct transfusion between animal and man, and naturally applicable to transfusion between man and man (even proposed in the venous by Colin). Generally they are two rigid cannulae joined by a flexible tube; but the tube can also be made of glass. In Dr. Gesellius' instrument (Fig. 3), the communication tube (A) is made of glass, and the two tubes, of which one (B) is intended for the animal and the other (C) for the human vein, are silver.

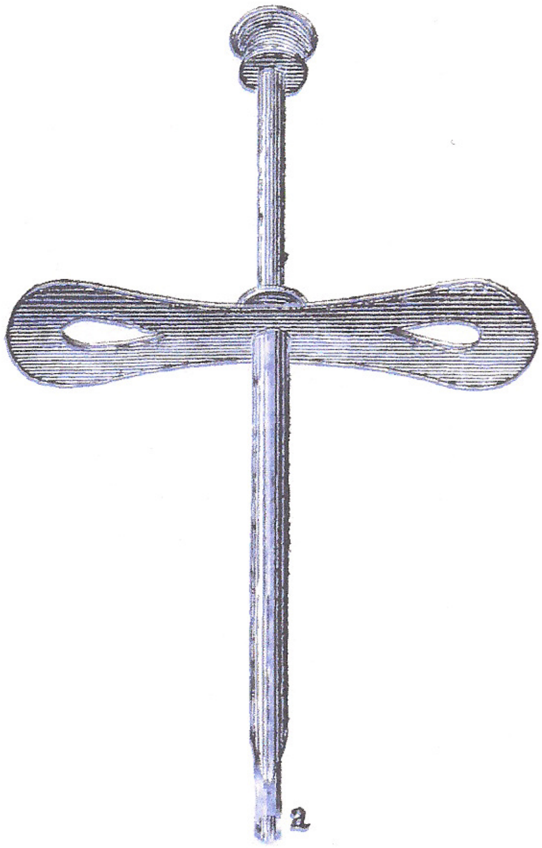
Fig. 3.



Albini has given us two instruments for direct transfusion, but so far he has only used them from animal to man. The first (1872) is his hemodometer, consisting of an elastic rubber tube with a lightness and thickness proportionate to the vessels on which it operates, with a length of 40-50 centimetres. To fix it, bring two metal or glass cannulettes at the ends, with the olive ends free outside, one of which is for the lamb's artery, and is fixed to it with a lace, the other is introduced into the previously discovered vein of the sick person. The second (1874) is only a complication of the first. He added a very ingenious cannula, which when closed prevents communication between artery and vein, and lets out the first blood that could contain air; subsequently opened establishes the communication. It consists of two concentric tubes, one of which is longer and enters the other which is shorter, each carrying a diaphragm with an eccentric hole at the same end, so that the two holes only fit together in a certain position. Another parietal hole lets the blood escape, and the holes are placed in such a way that when two of them communicate, the others do not match. This instrument has the advantage of opening or closing vascular communication, but it has the significant disadvantages of forcing the blood to pass through a narrow hole, of being complicated and of leaving a vulnerable instrument within the vein.

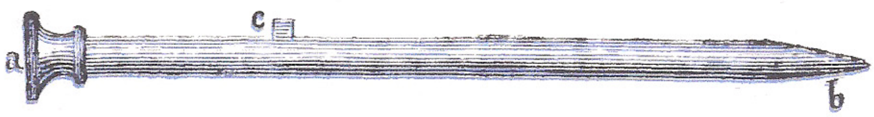
The instrument for direct transfusion proposed and extensively tested by Caselli is much superior to other transfusion instruments in which physiological blood pressure is used. Here is the description given to us by its inventor. The instrument consists of two cannula-needles (Fig. 4), cut in the shape of a clarinet beak, 5 centimetres long, equipped with two auricles, and one of these has about it half a grooved rise, on which a thread can stop. On the free end of these needles, in correspondence with the auricles, there are two frets (see the left needle-cannula in Figure 7) to accommodate the rise which arises from two flat spindles which slide into the two needle-cannulas.

Fig. 4.



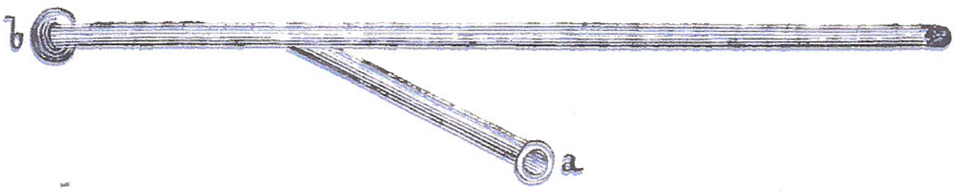
These spindles (Fig. 5) while on one side they end in a large shredded button (*a*), on the other they are shaped in an inclined plane like the end of the perforating cannulae (*b*); but the points are blunt and so exceed the stinging parts of them as to render them quite harmless and obtuse. The spindles, not far from the button, have a riser or stopping point that adapts to the fret engraved on the needle-cannula (*c*).

Fig. 5.



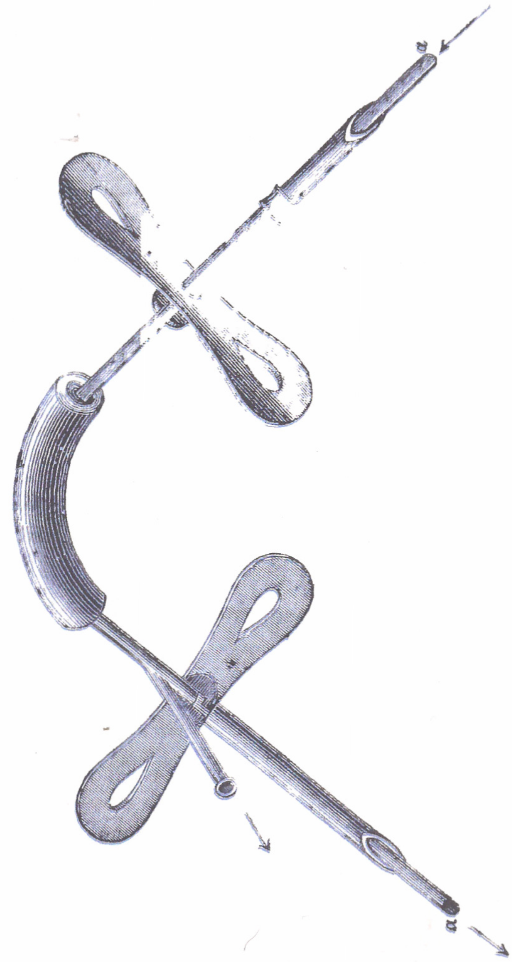
Each spindle has a number on the button that corresponds to another, engraved on the pavilion of the cannula needles so that no change of introduction occurs. Then there are two straight cannulae (Fig. 6, and Fig. 7 *a*, *a*) of the same diameter as the spindles, 8 centimetres long, joined by a piece of elastic rubber tube (see Fig. 7) not exceeding 3 centimetres long. One of these cannulae has a Y-shaped bifurcation (Fig. 6) which detaches at an angle of 25° and at a distance of 2 centimetres from the insertion riser of the elastic tube (*a*), following however the direction of the free end of the straight cannula. This branch is 2 centimetres long.

Fig. 6.



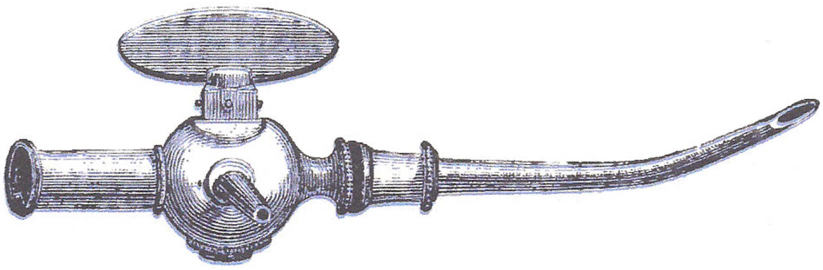
This instrument, though in my opinion leaves little more to be desired than simplicity, has been used with advantage in several transfusions, and I myself, who have attended it, cannot but commend it. When the instrument is in the moment of communication between the two vessels, it has the shape presented to us by Fig. 7.

Fig. 7.



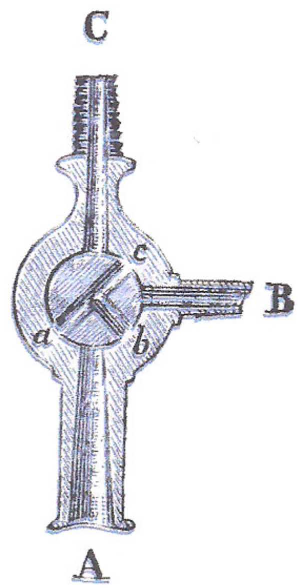
At first the needle-cannula is inserted with the spindle fitted with the thread riser (the one on the right) inside the vessel (artery) of the man or the animal who gives the blood, then the spindle is pushed forward so that the tip does not injure the walls of the vessel, and the spindle will be fixed, making its button enter the fret of the cannula. The instrument is then fixed to the vein by tying it with a thread at the riser. The same will be done for the patient's vein. After taking the rubber tube with the two cannulae, the simple one is introduced into the first needle-cannula by rapidly removing the spindle, and the other cannula with the branching is made to enter the needle-cannula placed in the vein of the patient. The jet of blood that comes out of the cannula prevents the entry of air, and since from both cannulae there is an exit of blood, so it is easy to make the instrument communicate without danger, at least on this side.

Fig. 8.



I cannot describe here other instruments proposed or used for direct transfusion; they are already too many in number and many have no practical value. But I must make an exception for the excellent and simple instrument of Professor Luciani (4), which consists of a 40 cm long rubber tube, one end of which, destined for the animal's artery, carries a lamp-shaped pulled glass cannula, and the other a curved cannula (Fig. 8) with a blunt tip and cut into a beak which, after opening with the lancet, is introduced into the patient's vein. A *double-way tap* is interposed between the cannula and the rubber tube, through the movements of which the tube can communicate both with said cannula and with a lateral tube (B), which serves to ascertain the existence of the blood stream. This dual communication is made possible by means of a T-shaped channel carved into the tap, the ends of which (*a*, *b*, *c*) correspond to the three internal holes of the cannula and of the tube (Fig. 9). The instrument could not be simpler, and on the other hand this tap system has already been put into practice with the advantage of more transfusion instruments (5).

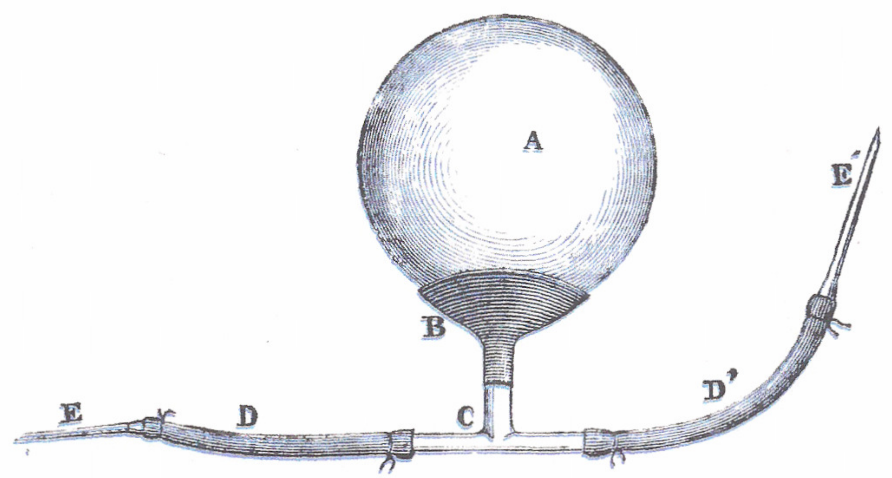
Fig. 9.



Postempski's instrument (6) seems less advantageous to us, of which Professor Vizioli has already rightly mentioned. Two lancet-terminated cannula needles are screwed together with a rubber tube interrupted in the middle by a glass tube. One of the cannula-needles has a tap which serves to make the air flow out of the device. As for the glass tube, according to its inventor, it should serve to let us know whether there is a current of blood. But the instrument is complicated by the screws, and the glass tube leaves nothing to be seen.

Artificial pressure instruments – If a compressible vessel filled with air is added to the communication tube, the pressure exerted on it will help the physiological impulse possessed by the blood flowing in the tube, and thus introduce it into the vein. Mathieu (1853), Aveling (1864), Rouget (1865), Oré (1865), Roussel (1873), Del Greco (1874), built instruments of this kind. In general it is a sphere of natural rubber to which the two communication tubes between the blood vessels are connected. The vacuum is made by pressing on the sphere, and when this is full of blood it compresses and releases alternately in order to simulate the movements of cardiac systole and diastole. The maximum advantage of these instruments is that the blood does not come into contact with the air, and that it can inject itself intact and directly, even when the pressure it possesses is insufficient to overcome the resistance offered by the venous vessel. However, the presence of air inside the container (mostly a natural rubber ball), making it possible to introduce it into the vein, diminishes the merits of this type of instrument. It seems to me that such an accusation can be done less to the primitive instrument of Aveling than to all those who are a simple modification of it. The Aveling instrument (7) is a rubber tube in the middle of which there is a fusiform swelling, pressing on which pushes the blood forward. It is clear that if one waits for it to be fully filled with blood, all the air will be expelled and there will be no danger. The Aveling instrument is therefore quite simple, and Landois accepted it too, albeit slightly modifying it with the addition of two taps and the usual lateral cannulae for the gushing of blood. Simply squeeze on the tube first, then the bulge to push the blood forward. The addition instead made by Roussel, of two valves close to the blood vessel, is completely useless.

Fig. 10.



In our opinion, Dr. Del Greco has unhappily modified the Aveling instrument (8). By changing the position of the air container (Fig. 10, A), and placing it in communication by means of a lateral branch (BC) with the communication pipe (DD'), he thus forces the liquid to deviate from its way to fill the container and leaves no security against the possibility of introducing at least some gas bubbles contained by the ball of natural rubber A. On the other hand the artificial pressure, acting sideways and in a perpendicular line, it is not clear how it could make a liquid flow from the ends E' to E; but, according to the simplest hydraulic laws, it would act by pushing back the blood, or by breaking the current. I therefore must give every preference to Aveling's instrument, which did not need this modification to fulfil its purpose.

If a simple elastic rubber tube is used (always preferable to any rigid tube), artificial pressure on the walls of the instrument can also be added to the spontaneous impulse of the liquid; in this way the blood will be pushed, if the physiological impulse possessed by it is judged insufficient, but one will have the disadvantage of not being able to calculate even approximately the quantity of blood that passes.

Another series of instruments in which the blood passes without air contact is the one where, the original pressure being considered insufficient, the current is helped by a pump body placed on the liquid path. Generally speaking, this is a suction and pressing pump, equipped if necessary with valves which allow the outflow of blood only in a given direction; the aspiration exerted by the ascent of the plunger causes the blood to come out of the blood vessels of the donor individual, and the pressure exerted by its descent causes it to penetrate the tube and from there to the open vessel of the patient. This manoeuvre is done for a short time, so the blood remains liquid and warm, and the instruments in question are the best for all transfusion methods. As they were built especially for the mediated transfusion of whole blood from man to man, so I will describe some of them later. Professor W. Howe, who practices direct transfusion between vein and vein, was also based on these principles, with the means of the slightly modified Dieulafoy aspirator, thus pumping the blood that passes vitally from one vein to another (9).

2. Instruments for indirect transfusion.

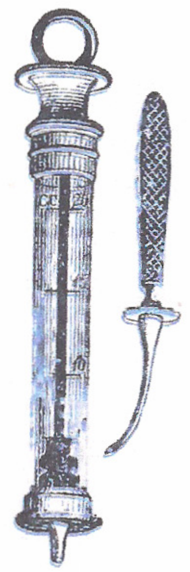
More numerous and complicated are the instruments for indirect transfusion. The difficulties of keeping the blood alive or injecting it without danger of air and clots being more serious, it was natural that the supporters of this method used all the devices, all the possible instrument to remedy them. The practice of defibrination has multiplied the methods and therefore also the instruments; but very many of them could be equally useful if defibrinated blood were used as well as natural blood. We will limit ourselves to giving an idea of the main ones, referring moreover to Belina’s book (10), where most of the devices due to the fervid imagination of transfusors are described and illustrated.

Instruments for indirect transfusion with defibrinated blood – The pressure that pushes the blood into the open vessel of the transfused individual can be artificially exerted by means of a plunger, but air pressure can also be used for this purpose.

The simplest transfusion instrument that meets the first condition is a tube or pump body, inside which runs a plunger, or in other words the irrigator, to which Wolfs exclusively attributes all the advantages (11); but to obviate the danger of the air, truly monstrous ones have been built.

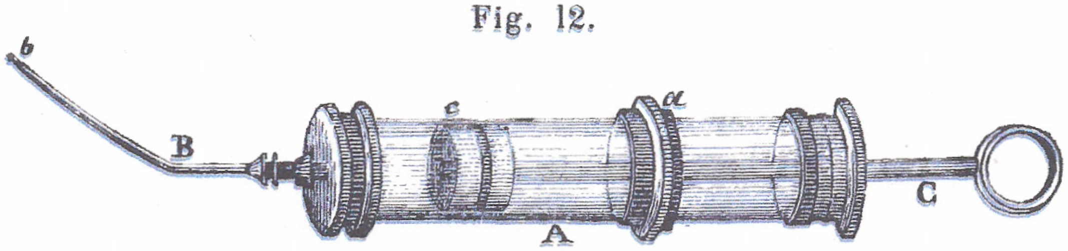
However, the best will always be the simplest. Polli and Prejalmini made their transfusions using an ordinary irrigator as Blundell, Goudin, Marmonier and Nélaton himself at different times did; in France even the common hydroceles irrigator has been used, and in many cases the Dieulafoy syringe. The transfusion was finally carried out with a *special* irrigator and syringes. Dieffenbach used a simple irrigator of tin, with a capacity of two ounces, fitted with a bent cannula. Blasius used a glass irrigator with a natural rubber [guarnitura] and a capacity of one ounce. Eulenburg and Landois used an equivalent one of 5-6 ounces, which could be graduated, and provided with an air vessel (Luftfänger). This vessel is a glass cylinder closed above and below by two rubber covers, which is inserted between the irrigator and the cannula, and communicates by means of an opening with the outlet channel of the pump body (12). Martin used a glass syringe with a conical cannula, containing 2 ounces of liquid, and to open the vein he used a curved trocar, the case of which functioned as a cannula (Fig. 11).

Fig. 11.



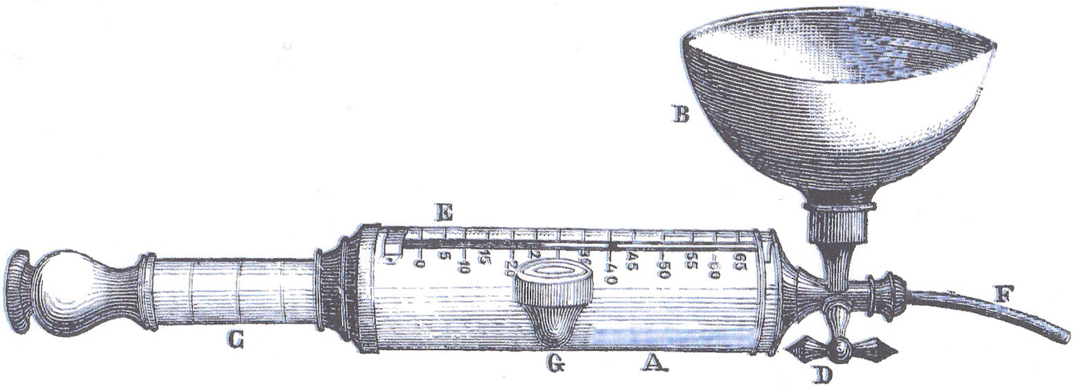
Uterhart, to prevent the entry of gas bubbles, made the outlet of the pump body sideways, also inserting the cannula laterally; thus the bubbles are pushed to the bottom of the instrument. Oré, for fear of injecting small fibrinous clots, added a small metal mesh stretched over the extreme opening of the irrigator to stop them being injected. In general, all these instruments have the shape of a common syringe, like that of Braune (reduced in Figure 12 to about a third of its size) to which Professor Landi from Pisa gives preference (13). In fact, the plunger (C) in this instrument is equipped with two leather discs (*c*) arranged in such a way as to act as valves in the upward and downward movements of the plunger itself. A riser (*a*) in the middle of the pump body (A) serves to keep the instrument fixed. As for the tube (Bb) this remains strongly screwed to the irrigator, being able to handle more easily due to its curve. The irrigator that Hüter used for his arterial transfusion is analogous to that of Braune, except that it is smaller and made of metal, and the cannula is not joined to the pump body, but is introduced first and tied within the vessel (artery).

Fig. 12.



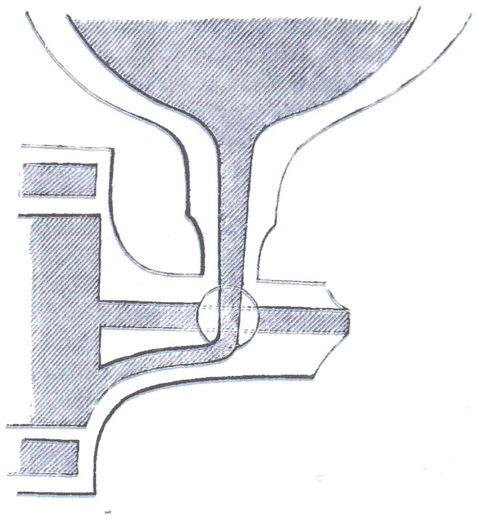
A special set of transfusion instruments, is one in which there is a mechanism that allows new blood to be introduced without removing the irrigator from the vein. Generally they are syringes equipped with a bowl, in which the blood to be injected is collected; this bowl communicates by means of a tap with the pump body, and thus the defibrinated blood, put into the cup, can pass at will in the irrigator for that quantity that is judged to be convenient.

Fig. 13.



I have no doubt in asserting that these are the best instruments for indirect transfusion, whether with defibrinated blood or with natural blood. Blundell's instrument belongs to this series, and consists of a copper irrigator equipped with a funnel-shaped tank in which the *non-defibrinated* blood was received; by withdrawing the plunger and opening a tap, the blood entered the pump body and was then pushed into the veins of the patient. Coppello's apparatus (14) is none other than Blundell's slightly modified. A common syringe (A) is fitted at the front with a funnel-shaped cup (B), in which the blood is collected. The funnel is in communication with the pump body for a channel in which there is a tap (D). By turning the key in the given direction, the funnel communicates with the syringe; by turning it in the opposite direction, the pump is put in direct communication with the tube (F), through which the blood is injected. Figure 14 gives a cross-section of this ingenious mechanism. The pump body is surrounded by a concentric container with an opening skin (G) in which hot water is introduced in order to heat the apparatus to that degree of temperature which is considered most convenient. A thermometer (E) placed on the syringe serves this purpose. The plunger (C) then has divisions corresponding to certain quantities of blood contained in the syringe.

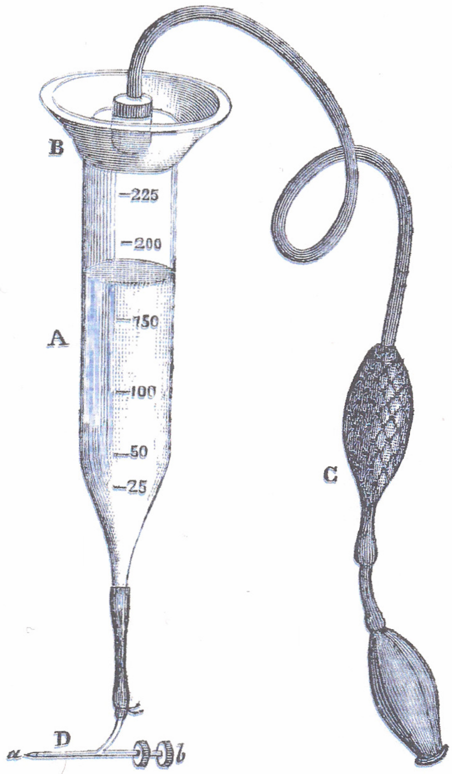
Fig. 14.



Von Graefe, who used Blundell's apparatus, also placed it in a container full of hot water, the temperature of which was recorded by a thermometer.

Pajot has built another syringe of this kind, but the funnel instead of being at the front end is at the rear of the pump body, and in the walls of the syringe there is a hole that can let the air, possibly introduced with the blood, escape. On the other hand, the idea of the funnel, from which the blood passes directly into the syringe, has also been used in instruments for indirect transfusion of blood in nature, and even very recently we have seen with great amazement the instrument presented by Coppello, just a little modified, as a new transfuser (15). With the exception of the concentric apparatus for heating the tube, Dr. Leblond's apparatus is a hoax of that of Coppello: even the funnel occupies the same position. Only the play of the tap, being T-shaped, differentiates it: but this form is copied by Luciani and Landois, and the botched instrument proves nothing but the goodness and excellence of the idea implemented by the aforementioned authors.

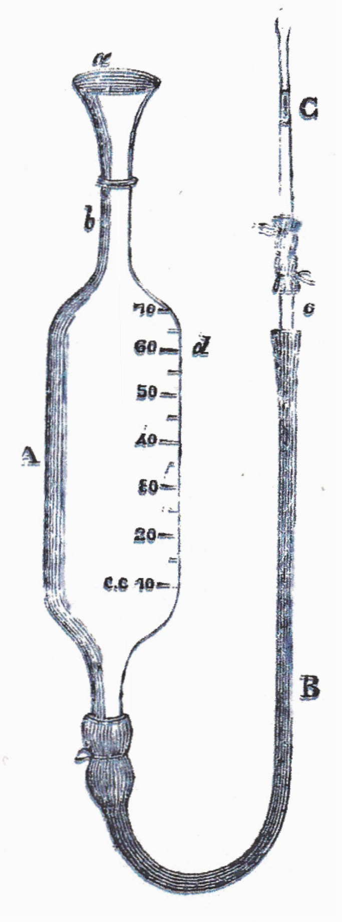
Fig. 15.



You can also transfuse defibrinated blood using instruments in which the pressure is exerted by means of air, whether an insufflation is carried out through elastic reservoirs, or whether the atmospheric pressure performs by itself on its own. Belina's apparatus (Fig. 15) takes advantage of the impulse exerted by a compressed air pump (C), made up of two balls of natural rubber joined by a tube. This pump is analogous to that of Richardson's apparatus for local anaesthesia. A container (A), which can hold 225 grams of blood and which bears a graduated scale on the external wall, ends at the top with an orifice (B), closed by a perforated natural rubber stopper. A button-shaped ivory cannula passes through the hole in the cork, to which the air pump tube is inserted. At the bottom, the container (A) carries a trocar, made up of two silver angled tubes and a silver stiletto. The trocar is intended to be introduced into the vein. After filling the vessel with blood, leaving an air chamber at the top, the tube is introduced into the vein and the pump is activated. The air compresses the surface of the liquid and this penetrates more or less uniformly into the vein (16). An instrument proposed by Dr. Tenderini (17) is also fashioned on this principle, where however the air pump is replaced by the lungs of the doctor, who must push the blood by dint of blowing (!).

Instead, to take advantage of the simple atmospheric pressure, and of the gravity of the liquid itself, Blundell, Schatz, MacDonnell, the Casse, have given us other transfusion devices, the hydraulic principle of which is this: the more considerable a column of liquid is, the more it rises, the greater its pressure on the bottom of the vessel. Blundell called his the gravitator, precisely because he took advantage of the law of gravity of bodies; and in general they are all vessels of varying length, ending in a tube to which is coupled the cannula to be introduced into the vein.

Fig. 16.



MacDonnel's instrument (18) (Fig. 16) consists of a container (A), of known and graduated capacity, surmounted by a funnel (*ab*), through which the blood is poured. A rubber tube (B) carries the cannula (C), equipped with a lateral hole which is introduced into the patient's vein. The tube is interrupted at point (*c*) by a glass tube to allow blood to be seen. When the blood (defibrinated) and the cannula are in place, by lifting the container the gravity of the liquid itself tends to make it flow downwards, and the higher the height to which the vessel is brought, the greater the pressure exerted on the liquid column below the container.

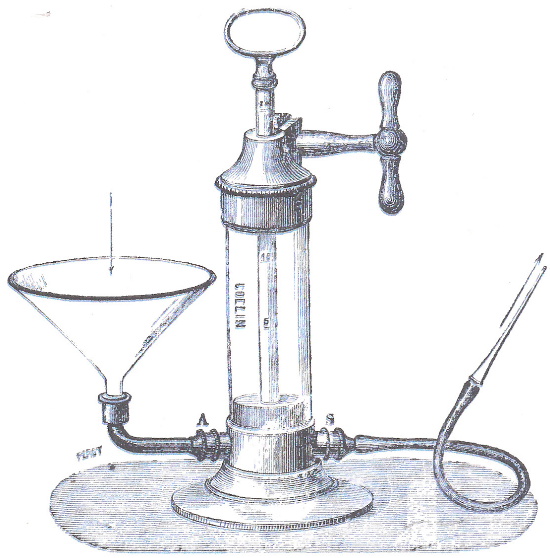
Dr. Casse (19) made himself known for modifying the ideas of Blundell and MacDonnel, only by complicating the cannula that is used to introduce blood into the vein, which, moreover, is nothing more than a very complicated trocar, in whose cannula-case the blood enters from the side through a funnel-shaped lateral branch arranged at an angle. As for Schatz, he used to introduce defibrinated blood by the force of its weight alone, using a graduated chemistry tube, terminated at the lower end by an elastic tube, equipped with the usual compulsory device (20). However, since the blood has to stay there for a certain time, these instruments can only be used in the transfusion with defibrinated blood, while with all the others it is also possible to transfuse intact blood; and it is what makes them the most disadvantageous of all, especially since it is not possible to calculate a uniform and regular pressure. In veins in which the pressure is at a *maximum* of 3 centimetres, measuring it with the height of the pressure gauge, it will correspond to a water column equal to 13.196 (specific weight of mercury) x3 = 40 centimetres approximately. But with Casse's instrument, and also with the others, the blood flow will lower the pressure, so it will be necessary either to pour in more defibrinated liquid, or to raise the instrument a lot, otherwise the resistance is not overcome by the power. These obstacles minimize the advantages of these instruments exposed by Thirifay (21), that is, that the current is slow, uniform and continuous in them.

Instruments for indirect transfusion with natural blood. – These constitute the most beautiful page in the transfusion technique, as they are based on the physiological principle of injecting the blood with all its properties, and because they have overcome dangers, which up to now were believed to be indivisible from this operation. Collecting the blood as soon as it comes out of the blood vessels of an individual and injecting it immediately, without air and without clots, still alive and hot, - these are the extraordinary advantages of these devices.

The first instrument of this kind, the unrecognized father of all the others, dates back to the seventeenth century, and is from Mayor, who attributed the discovery of the transfusion to himself (22). A 2-finger long glass cylinder, containing 5-6 ounces of liquid, carries at one end a curved tube whose mouth is shaped *like a suction cup*: the other end of the cylinder is thin and enters the patient's vein. Once the vein of the healthy man is opened, it is immediately applied over the suction cup and so the blood flows through it without air entering. When the surgeon notices that the cylinder is full, he then pushes the blood with a plunger into the patient's vein. The danger of air and that of clots is thus obviated by Mayor, preceding all the modern inventors, who have presented us with instruments not very dissimilar from that without, however, mentioning their authorship.

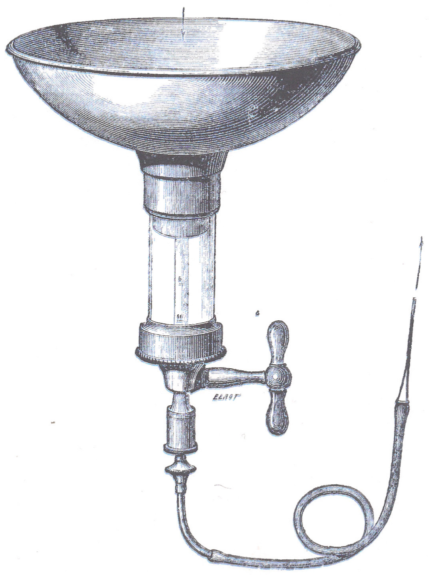
Among the instruments with which the blood collected alive and warm is immediately injected into the vein, I have already described those of Coppello, Leblond, Blundell and Pajot, which can be used both for defibrinated blood and for intact blood. Dr. Moncoq of Caen made a lot of noise about his instruments (23), which, if it is true that they have indisputable advantages, are therefore no less simple modifications of previous instruments. The first of them (1862) was based on these principles: 1° injection of intact blood; 2° instant injection, in order to avoid blood clotting and death, and therefore do not to take the blood from the vessels only to the extent of its passage; 3° subsequent injection and for small blood waves; 4° injection from atmospheric air; 5° immediate injection of blood between man and man. The instrument was composed of a pump body, the plunger of which could be set in motion by means of a gear crank. Two tubes terminated in the lower part of the pump body, one to serve for the arrival of the blood, the other for communication with the vein of the animal (or man) to be bled. The internal orifices of the two tubes were equipped with two valves opening in the opposite direction, but the Moncoq then rightly abolished them. This excellent instrument (whose mechanism is well understood) allowed blood to pass from one animal to another, acting as an artificial ventricle equipped with true systole and diastole. Moncoq experimented with it and found it very useful in animals. For the transfusion in man (1864) he modified his first instrument, replacing the tube for the arrival of the blood with a funnel, in which the blood can be collected, during the same bloodletting, from the healthy man (see Fig. 17).

Fig. 17.



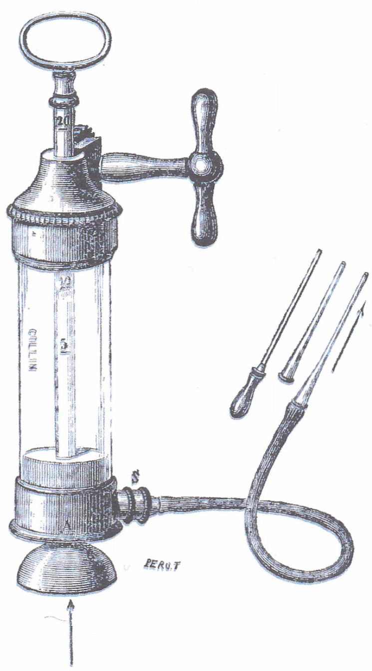
The Moncoq instrument has the advantage of the instruments indicated by Coppello, Pajot etc., indeed it can be said to be nothing other than the modified Blundell instrument. Its inventor attributes the following advantages to it: 1° rapid and instantaneous passage of the blood, which does not leave the vessels except for a short time; 2° avoided coagulation; 3° blood pressure and pulse regulated by the plunger; 4° exact measurement of the transfused quantity (by graduation of the plunger rod): 5° avoided the danger of introducing air. Regardless of Moncoq's exaggerations, the instrument seems to us very good, and best of all the modifications brought to it by Mathieu. Mathieu presented in 1874 an instrument (Fig. 18), which is none other than that inverted Moncoq: that is, the funnel for receiving the blood is placed above the pump body, communicating with the injection tube by means of a channel cut into the inside of the plunger rod. It is an unfortunate modification, which will be ingenious for a mechanic but anti-physiological for a doctor: and Moncoq is right in this. The long journey of the blood through the plunger, its passage through valves, the impossibility of seeing if there is no air in the upper part of the vessel, and the lack of a fixed point of support, make the advantages of this device very doubtful, although Bèhier and others could use it without danger.

Fig. 18.



Moncoq, further modifying his instruments, gave us a third for immediate transfusion (1864-74), but if he was jealous of his own priority rights, he should have recognized those of others as well. Just as the instrument we have figured (Fig. 17) is only a transformation of those of Blundell and Coppello, so his last one is of the primitive instrument of Mayor (24). The lateral funnel or the upper cup are replaced by a suction cup placed under the pump body (Fig. 19), with which it communicates by means of a valve (A). Once the vein of the healthy man is pierced, the suction cup is lightly applied and the blood is sucked with the plunger, which is then pushed through the injection tube with a downward movement, also equipped with a valve (S) opening in the opposite direction to the previous one. As can be seen, this apparatus is the same as that of the Mayor, but has the serious drawback of not leaving safe against the entry of air; so we must give preference to the primitive instrument of the Moncoq.

Fig. 19.



A much more complicated apparatus is that of Roussel (25) built by him especially with a view of transfusing directly from vein to vein, without danger of introduction or contact of air and without the inconvenience of introducing a cannula into the vein of the healthy man. It consists, like the previous ones, of a suction cup that rests on the previously inflated vein of the arm, under which, after having made the vacuum, the vein itself can be pierced with a lancet; the blood collected by the sucker is, by means of a tube, then led to the vein of the patient, as in the common apparatus of Aveling. But the instrument is so complicated that the description provided by Roussel himself is insufficient to make the mechanism understood, and on the other hand it has no real advantage over other simpler, less expensive and more manageable instruments.

Dr. Leblond, who re-presented the Coppello device to us as his own, modified it for direct transfusion. By removing the dome, he inserts another tube into it, and thus can put one individual in communication with another, the plunger by absorbing the blood from the healthy one and then pushing it into the prepared vein of the patient. The usual T-key as in Luciani's instrument allows you to alternately open and close the communication. I need not say that such an instrument is very reminiscent of the first instrument of Moncoq (1862), presenting only the orifices for the tubes in a complementary part of the pump body and not in the lower part of it. But the strangest is that Dr. Ridolfi of Brescia presented in June 1875 to the Milan phrenetic society an instrument similar in all respects to that of Leblond, to which he added nothing but an index on the tap, which allows you to know on which side the communication exists. I have nothing more to say about these inventions, which tumultuously succeed one another without concern to justify their true origin.

The Leblond-Ridolfi instrument has several advantages. If the two tubes lead to the vascular ends two cannulae which are easy to introduce and which do little to damage the vessels, it will be possible to carry out easily with it, as in general with all instruments of this species, both direct transfusion from man to man, as well as animal transfusion. The same advantages are presented by the recent Schliepp instrument (26), set in motion by means of a pump, acting as a ventricle, and by means of an ingenious opening, equipped with the usual T-valve, secured against the introduction of air. Double arterial transfusion (Bruberger) can also be performed with Schliepp's instrument.

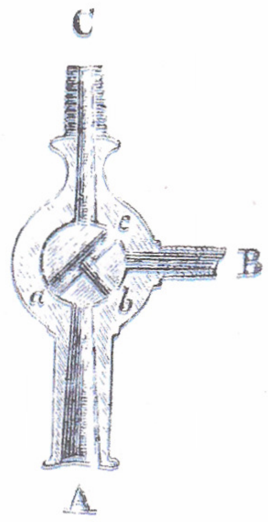
It therefore appears that today, thanks to these improvements in the technique, we can transfuse fresh blood from man to man, even if we use venous blood, and the pressure in the veins is so low. Blood flow free from air contact, ready injection without clots and under determined pressure, known quantity of transfused blood - such are the advantages of this intermediate method of transfusion between direct and indirect, to which could be kept the name *immediate transfusion*.

3. Determination of the amount of blood transfused.

Determining the amount of blood transfused has always been a concern of transfusors, since in this way the effects of the operation can be calculated more precisely: but this is not possible in all methods, nor do all instruments lend themselves to such an important calculation. In pump body instruments, the capacity of which is known, the dose of blood is easily calculated: either the plunger carries, as we have seen, the indication of cubic centimetres and grams, or there is a scale on the transparent walls of the device. as in the common chemists' test tubes, which allows calculation of the quantity of liquid that is introduced into the tube. If the instrument is small, and its opaque walls do not lend themselves to measuring the internal level of the liquid, it is enough to know its capacity because, taking into account the times in which it has been filled and emptied into the vein, the exact dose of injected blood can be obtained. But in the instruments with direct communication, formed mostly by a tube in which the blood passes with the initial speed and pressure possessed by it in the blood vessels of the individual (or animal) with blood, it is absolutely impossible to determine the quantity of blood, so there is a risk of transfusing more or less of what was deemed appropriate. In this way the relative value of the transaction is greatly decreased.

Many means have been proposed for determining the amount of blood transfused by the direct method. The most common is to calculate the time taken by the blood to come out in *given quantity* by the opening of the instrument (Hasse, Luciani, Postempski, Caselli). Luciani thus estimates that: *at the same time, the same amount of blood passes into the patient's vein through the cannula of the instrument, as it passes outside at a free end*. Thus for example wanting to transfuse 100 cubic centimetres of blood, and it has been proved that it takes 6 *seconds* for *ten* centimetres of blood to exit from the instrument, it will take 6 x 10 seconds or *one minute* for the required amount of blood to pass into the patient's circulation. In order to have an exact proportion between the various cannulae of his instrument, Luciani has constructed the same in such gradation, that the maximum and the minimum cannula (AC) have openings in relation to the opening of the lateral tube (B) (Fig. 20) such as :: 2: 1, and :: 1: ½.

Fig. 20.



A similar process is used by Prof. Caselli with his instrument for direct transfusion from animal to man, except that he weighs the blood coming out of the cannula for a known time and calculates the quantity in grams. In short, by calling S the quantity of blood exiting the cannula for a given time *t*, and T the time in which the communication between the two individuals lasts, Postempski establishes the following proportion:

$$t : S :: T : x, \text{ from which } \frac{T \times S}{t} = x$$

x = the amount of blood transfused.

This method is very doubtful, and can only give us the required quantity by approximation. We have already mentioned elsewhere the physical conditions of vascular pressure existing in transfusion (page 209 and following); and it is by relying on these haemodynamic facts that we must regard with great suspicion a method of calculation based on such variable elements. First of all, the resistance encountered by the blood in its exit from the cannula increases with the friction of the vessel walls: blood flows to the free air from the open end of the instrument in conditions very different from those practices of transfusion. And indeed, will the blood pressure in the transfused vein not affect the amount of fluid flowing through it? Panum tells us that it will not only decrease, but completely hinder the outflow of blood, and when one thinks of the very small amount proposed by many transfusors, one can believe that the transfused dose in such cases was absolutely minimal. The reasons opposed by Dr. Lelli also seem quite right to us. He, taking into account the blood pressure by means of a manometer, saw the blood pressure increase significantly (in some cases almost double) as soon as the transfusion communication between two animals was established; and the increase was such that it almost reached the figure of pressure given by blood with the *tube completely closed*. It can therefore be assumed that in this case the amount of blood passed through the cannula immersed in the vein would have been just half of the quantity released from the cannula into free air. In short, if it is true that the *quantity of blood that passes is in inverse proportion of its pressure, or of the squares of the pressures* (Lelli), it is easy to understand that in the direct communication between vessel and vessel, increasing the resistance encountered by the blood is both for the friction and for vascular pressure, the quantity transfused will always be less than the calculated quantity. Nor is it worth believing in all those physiological influences which, according to some, can increase rather than decrease the blood flow in the case of communication between two vessels; one cannot forget the hydraulic axiom that any resistance increases the pressure of a flowing liquid, and in the case of direct transfusion no one will ever deny that the resistance has not increased. Certainly we do not agree with the Panum when he firmly denies any passage of blood: blood will pass, but never in a determinable quantity, as the circumstances that can increase or decrease the vascular pressure are too varied. In cases of decreased blood tension due to vacuity of the circulatory system (haemorrhage anaemia) it will be easier for the calculation to approximate the truth: but where the physical conditions of the circulation are normal, the calculations and the proportions mentioned will be of little use.

Dr. Lelli, raising doubts about the arithmetic method of the transfusors, proposed to apply a manometer to the communication tube, namely at the end introduced into the transfondant's vein, being able, according to him, to deduce the pressure encountered by the blood during the transfusion from the height of the manometric column, and from the pressure encountered then the quantity transfused. The relationship would be inverse, the higher the pressure, the less liquid passed into the vein. The idea seems happy to us, especially since the manometer could indicate whether the current has been interrupted due to a clot formed in the cannula or in the vein (Lelli); and if the quantity transfused were to be always in inverse ratio of the squares of the pressures, one would have a mathematically exact means of calculating it. But there are very uncertain physiological conditions in this practice: the vascular pressure can vary at any moment, and the calculation can be disturbed by a sudden elevation or lowering of the manometric column. Dr. Lelli then gave us too little experience, and he does not even tell us why the simply inverse proportion between pressure and quantity is changed by him into the more complicated proportion between squares of pressure and quantity transfused. We are therefore entitled to await further arguments from him.

A counter mechanism is the one applied by Dr. Noël (27), which consists of a wheel, of determined circumference, around which the transfusion tube turns. Each revolution of the wheel drives a known quantity of blood into the vein, so that if you know the number of revolutions, you will have the transfused dose. But this device is rather complicated, and we don't even know if it was ever used. Many ideas seem theoretically acceptable, but practice quickly takes them out of the field of science.

As can be seen, transfusors have very little means of calculating the true quantity of blood in direct transfusion. Indeed, some have thought of taking advantage of the first effects of the operation, to suspend the intake of blood. Thus Hasse proposes to stop the current when dyspnoea occurs, and others think that the quantity that gives rise to redness and swelling of the face immediately after the operation is sufficient. Bèhier indicates a certain dry cough presented by transfusions, as a sign of intolerance of the lung to more blood. But besides, these symptoms may also not occur at all, as happens in many transfusions, the tolerance of individuals is so varied, that we will not be able to specify for sure based on the first effects of the operation. Dyspnoea, for example, occurs not only because of the amount of blood that is transfused, but more often for the speed (Ponfick). If the blood *stroke* (in direct artery-to-vein transfusions) is excessive, a small amount of blood coming with great force into the pulmonary vessels will produce rapid distension of a *limited* group of lung cells, and you may have dyspnoea or a dry cough even with a few grams transfused. In cases of general weakening, since the lung is normally supplied with a calm and regular arterial current, the speed and impulse of the transfused blood will exert an abnormal excitation, both on the walls of the small capillaries and on the air vesicles: and the irritation may appear as soon as the introduction of the new blood has begun. Therefore, no constant element possesses surgery to calculate the quantity of blood *in direct transfusion* (especially animal): one must therefore always act with precaution, thinking that the smaller the dangers of the operation the smaller the transfused quantity of blood.

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