ETUDES HISTORIQUES, PHYSIOLOGIQUES ET CLINIQUES SUR LA TRANSFUSION DU SANG

By: Dr PIERRE CYPRIEN ORÉ (1876)

A TRANSLATION OF PART FOUR (PAGES 633-695) OF THIS BOOK BY PHIL LEAROYD

INSTRUMENTS ET APPAREILS EMPLOYÉS POUR LA TRANSFUSION (Instruments and Devices used for Transfusion)

A copy of 'Historical, physiological and clinical studies on blood transfusion' by Pierre Cyprien Oré, published in 1876 in Paris [by J-B Baillier & Sons] can be viewed or downloaded from the following site:

https://books.google.co.uk/books/about/Etudes_historiques_physiologiques_et_cli.html?id=1KovAQAAMAAJ&redir_esc=y

NOTE: This is the second book that Pierre Cyprien Oré wrote on blood transfusion; his first, 'Historical and physiological studies on blood transfusion', was published in 1868. This 1876 book is not a reprint with a different title but has a different, more extensive content, being over 700 pages whilst the 1868 version had less than 200 pages.

NOTE: I have also translated the 'Historical Section' of this book (pages 1-61) into English – see separate document.

In the 'Instruments and devices used for transfusion' section of this 1876 book, Oré illustrates, documents and descries a number of different pieces of equipment devised by a variety of physicians and equipment makers that are designed to perform the alternative types of blood transfusion used at that time.

This chapter documents the different, sometimes very complicated, pieces of equipment used for transfusion during this period of the 19th century, many of which appear to have been produced by a process of 'over-engineering'. This seems to have been driven at least to some degree by the desire of individual physicians and equipment makers to design and market their own device, whilst appearing at the same time to somewhat ignore the great problems of whole blood coagulation or the difficulties associated with effectively defibrinating larger quantities of whole blood. Whilst knowing these problems exist, the author frequently appears to ignore these issues or at best contradict himself regarding them, whilst demonstrating the effectiveness (or otherwise) of particular devices.

Oré begins this chapter with direct (immediate) transfusion devises used by researchers in animal experiments to perform a transfusion of blood from an artery of one animal into a vein of another. These devices essentially involve a simple tube with a cannula at either end, with the blood flow being generated by arterial pressure from the donor to the recipient, similar to those used for the earliest transfusions performed between a donor animal and a human recipient by Jean Denis and Richard Lower in 1667.

The desire to develop the same type of device for use in humans, being from vein to vein, required the development of some form of artificial pressure to generate the blood flow between the donor and the recipient. Oré documents the simplest form of this to be the incorporation of a rubber (pressure) bulb within the connecting tube that acts as a pump, either with or without accompanying taps or one-way valves. This type of equipment then developed into some form of pressure mechanism, usually produced by a syringe being incorporated into the connecting tube together with one-way valves that could create a vacuum to move the blood from the donor to the recipient.

Indirect (mediate) transfusion techniques initially involved the collection of whole blood from the freely bleeding arm vein of the donor (as in bloodletting) into a vessel, which was then infused as quickly as possible into the patient's vein before it clotted. The simplest means of doing this was of course by transferring it into a syringe to inject into the patient's vein via a cannula. Oré identifies the different mediate transfusion devices that were subsequently developed that incorporated a 'collection funnel' together with some form of pump mechanism for the transfusion of untreated whole blood or defibrinated blood. The majority of these appear to have been 'variations on the same theme'.

It is interesting to notes that although James Blundell created his 'Impellor' in 1825 and 'Gravitator' in 1829, both of which were complex devices, he subsequently resorted back to using a syringe for mediate transfusions of human blood. It is also therefore interesting that, whilst Oré talks about the simplicity of the syringe in this chapter, written nearly fifty years after Blundell, physicians (including Oré) and instrument makers were still making complex pieces of equipment for mediate transfusions. This is well illustrated by the fact that 'Plate 6' in this book includes an illustration and description of Oré's transfusion syringe that is not actually referred to in the text of this chapter. I have included the information and associated description of this syringe at the end of this introduction.

This is one of four books written at around the same period that documents and illustrates different types of transfusion devices, the other three are by Ladislao von Belina-Swiontkowski (1869), Louis Jullien (1875) and Joseph Roussel (1876).

Although Oré begins this chapter of his book by defining the two ways of performing a transfusion, i.e. immediate and mediate, and starts to classify the instruments by these criteria, the text becomes more confused in that some devices were designed to be able to be used by both techniques; this is confused further by the fact that he also describes different types of equipment together using the name of the person who devised / manufactured them rather than by the transfusion method. The illustrations of the equipment are also confusingly presented. Some are included (in different orientations) within a series of six 'plates' at the end of the book (that are rather poorly reproduced in the scanned version of the book), most of which contain a variety of different line drawing illustrations. In addition, these figures are not presented within the plates in the same order that they are referred to within the text resulting in a somewhat random arrangement that requires the reader to move back and forth between the text and illustrations. These illustrations are also referred to within the text by means of a rather confusing shorthand format and the figures themselves are orientated differently within the individual plates. Other illustrations though are presented separately within the body of the text, either as numbered figures or as titled illustrations. I have separated the individual illustrations from within the plates and placed each of them (with a revised labelling notation) together with the others, so that all appear as individual titled illustrations within the appropriate place of the translated text.

The devices are identified within the text by the name of the physician who designed them, though this is also somewhat confusing at times in that some items of equipment are also identified by the name of the instrument maker, i.e. Mr. Collin and Mr. Mathieu.

The chapter includes the equipment designed by Morselli, Gesellius, Luciani, Casilli, Albini, Roussel and Oré, intended for animal artery-to-vein (direct) immediate transfusion; the equipment designed or made by Aveling, Grecco, Manzini & Rodolfi, Moncoq, Mathieu and Collin, intended for vein-to-vein (direct) immediate transfusion using artificial pressure; the equipment of MacDonnel, Casse, Belina, Coppello, designed to be used for (indirect) mediate transfusion of whole blood or defibrinated blood, and the equipment of Moncoq, Mathieu, Collin, Oré and Gendron, which is stated to be able to be used for either immediate or mediate methods of transfusion.

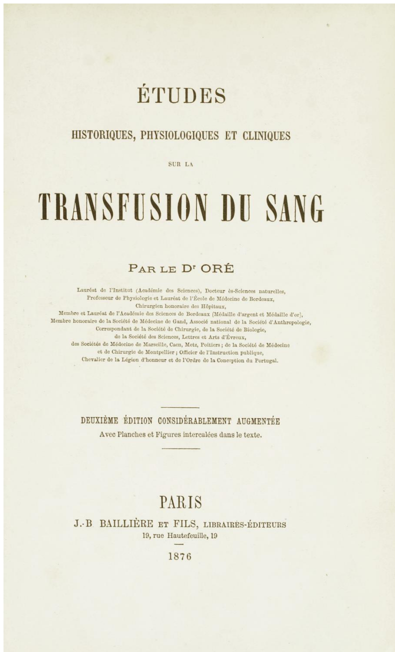
Although not admitting the inadvisability of employing whole blood for mediate transfusion using these devices, it is interesting to note that in his conclusions at the end of this book Oré makes the following statement related to obtaining human blood donors to provide blood for a potentially increasing numbers of patients: *We will therefore have to return to transfusion with animal blood, as the transfusers of the seventeenth century have done so successfully, as Italian doctors do today with no less success, and with them Hasse (from Nordhausen), Gesellius (from St. Petersburg). Physiological experimentation demonstrates the effectiveness of this method. Clinical observation confirms this. Hesitation is no longer possible.*

I have translated the section of this book from the original French into English in the hope that the content may be appreciated by a wider audience. Whilst I am obviously aware that instantaneous computer-generated translation is possible, this process struggles with specialist terminology and also produces a 'colloquial style' not always representative of the original text. I have purposely produced this translation to be 'un-interpreted', in that I wanted to maintain the author's original meaning / wording as much as possible. As with any translation the wording may be purposely or inadvertently altered to 'make it read better' but in doing so there has to be an element of personal interpretation involving something on the lines of 'I believe that this is what the author is actually trying to say'. I wanted to avoid that as much as possible and try to present what the author actually wrote and as such the reader may find that the English text does not 'flow' as well as it could. Although I have taken great care not to misrepresent the author's original wording I cannot guarantee that this work does not contain 'translational errors' and the reader is recommended to check specific details against the original French text. I have in a small number of places included words or comments in square brackets to explain a particular term or word used by the author.

PIERRE CYPRIEN ORE (1828 – 1889)
- BIOGRAPHICAL INFORMATION

Pierre Cyprien Oré was a French doctor, surgeon and professor of physiology at the Faculty of Medicine in Bordeaux, where he was born on the 15th November 1828. In 1850 he became a student at the medical school and then an intern at Bordeaux hospitals. His first thesis submitted in support of his doctorate in natural sciences, was titled 'Experimental research on blood transfusion'. He became a surgeon at Saint-André hospital, later becoming a professor of medicine at the faculty of Bordeaux. From 1860 he became very interested in blood transfusion research, publishing the first edition of his book 'Études historiques et physiologiques sur la transfusion du sang' [Historical and physiological studies on blood transfusion] in 1868, the second, much revised edition, being published in 1876. He later however experienced a number of practical blood transfusion failures and as a result, ceased this line of research, retiring from his teaching post in 1878. He continued to practice for ten years as a simple doctor. He was a corresponding member of the Savoy Academy of Sciences (1884-1889) and the National Academy of Medicine (1885-1889) as well as a Knight of the Legion of Honour. He published extensively on other medical subjects and was in 1872 the first person to successfully administer intravenous anesthesia (chloral-hydrate) and in 1875 he published the first monograph on intravenous anaesthesia in humans. He is stated to have been an amateur painter and poet as well as a collector, especially of ceramics. He died in Bordeaux on the 5th September 1889.

Pierre Cyprien Ore
(image credit: journals.sagepub.com)



ÉTUDES
HISTORIQUES, PHYSIOLOGIQUES ET CLINIQUES
SUR LA
TRANSFUSION DU SANG

PAR LE Dr ORÉ

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des Sociétés de Médecine de Marseille, Caen, Metz, Poitiers ; de la Société de Médecine
et de Chirurgie de Montpellier ; Officier de l'Instruction publique,
Chevalier de la Légion d'honneur et de l'Ordre de la Conception du Portugal.

DEUXIÈME ÉDITION CONSIDÉRABLEMENT AUGMENTÉE
Avec Planches et Figures intercalées dans le texte.

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1876

'Transfusion du Sang' (1876)
(image credit: adebooks.co.uk)

NOTE: This illustration and description, included within Plate 6, is not referred to within the text of section four of Oré’s book:

TRANSFUSION SYRINGE

I had this syringe constructed three years ago to fulfil a double purpose: 1) To practice transfusion in small animals; 2) Make intravenous chloral injections. It is based on the same principle as my 4th and 5th transfusers "fill alone and empty alone".

Description and mechanism: My syringe consists of a pump body H, with a capacity of 15 grams, which articulates in B, with the cannula that is placed in the vessels. The pump body is joined to the tube B, by a valve A, which allows or prevents the entry of outside air, depending on whether it is open or closed. This valve A, being closed, a vacuum is created in the pump body by raising the piston P, which is supported by a copper rod with rack. When it reaches the top of its stroke, the piston is immobilized by the pawl C, the acute lower end of which engages in an opening made in this same rod. When valve A is opened, the blood or the liquid to be injected rushes into the pump body and fills it.

To empty it, just lift the pawl C, the piston then executes a downward movement that is communicated to it by a steel spring contained in the box R.

All those who, for three years, followed my lessons or my laboratory, have often had occasion to see this syringe used.

INSTRUMENTS AND DEVICES USED FOR TRANSFUSION

OPERATING MANUAL

We could build a complete arsenal of the various devices proposed for the transfusion of blood. As such, my intention is not to describe them all, but to make known those who have played an important role in the practice.

We will divide these devices into two large classes: In the *first* class we will describe those that are intended for immediate transfusion. The *second* will contain those that are more particularly used for mediate transfusion.

FIRST CLASS - *Devices for immediate transfusion*

The first of all these devices is the one used by seventeenth century transfusers. It consisted of a series of nested [interlocking] quill pipes or tubes placed one after the other. One end of the tube is inserted into the vessel that was to supply the blood the other entered the vein that was to receive it. The animal was securely attached to avoid movements that would have hampered the regular operation of this device.

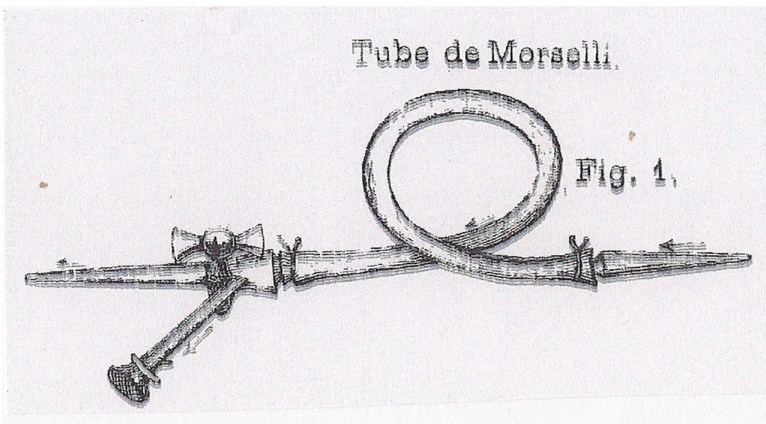
Later, at a time close to ours, Richard Lower's inflexible tube was replaced with a rubber tube that made it much easier to perform the operation. All devices for immediate transfusion have two things to consider:

(1) An intermediate part.
(2) The extremities.

We will see by the descriptions that we will make, that all these instruments have the greatest analogy between them and that they differ from each other only by simple changes in the details.

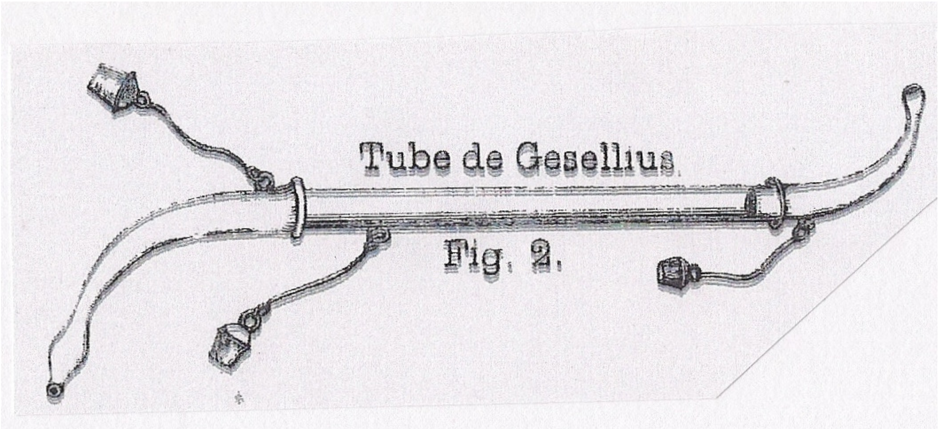
For physiological research, the simplest is a rubber tube, terminated by two cannulas, one of which enters the vessel of the one who gives the blood and the other into the vessel of the one who receives it.

The instrument Morselli (Plate 1, Fig. 1) (See: *La Trasfusione del sangue*, by Henrico Morselli, Torino, 1876, p. 320) used for his experiments was thus conformed; only he had a small cannula by means of which one could know if any clots had formed. In addition, communication between the two vessels could be interrupted by means of a tap.



Morselli’s apparatus (Plate 1, Fig. 1)

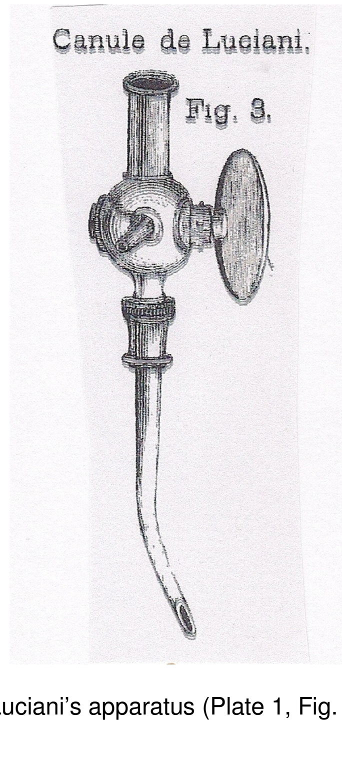
Sometimes the tube which serves to unite the cannulas, instead of being flexible, is rigid as in the new instrument of Gesellius. The communication tube is made of glass and the two cannulas of silver (Plate 1, Fig. 2).



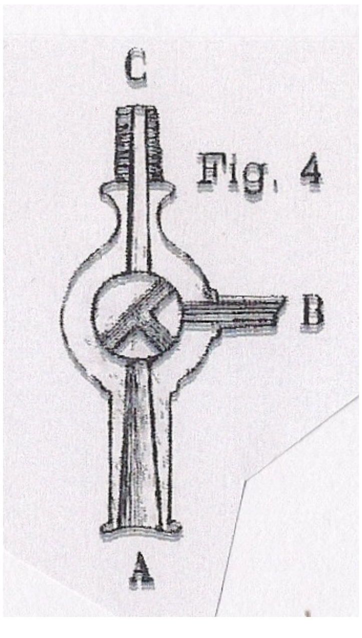
Gesellius' apparatus (Plate 1, Fig. 2)

Luciani's transfuser

Luciani's instrument (Plate 1, Fig. 3) is composed of a 40 centimetre long rubber tube, one end of which, intended for the animal carries a glass cannula, and the other a curved cannula with a blunt tip cut like the mouthpiece of a flute, which is introduced into the patient's vein. Between the cannula and the rubber tube is placed a small tap, the play of which allows the tube to communicate at will with either the cannula or with the lateral opening B, which serves to verify the existence of the blood stream. This double communication is obtained by a T-shaped channel, hollowed out in the tap, and whose ends, A, B and C, correspond to the three internal openings of the tube (Plate 1, Fig. 4).



Luciani's apparatus (Plate 1, Fig. 3)

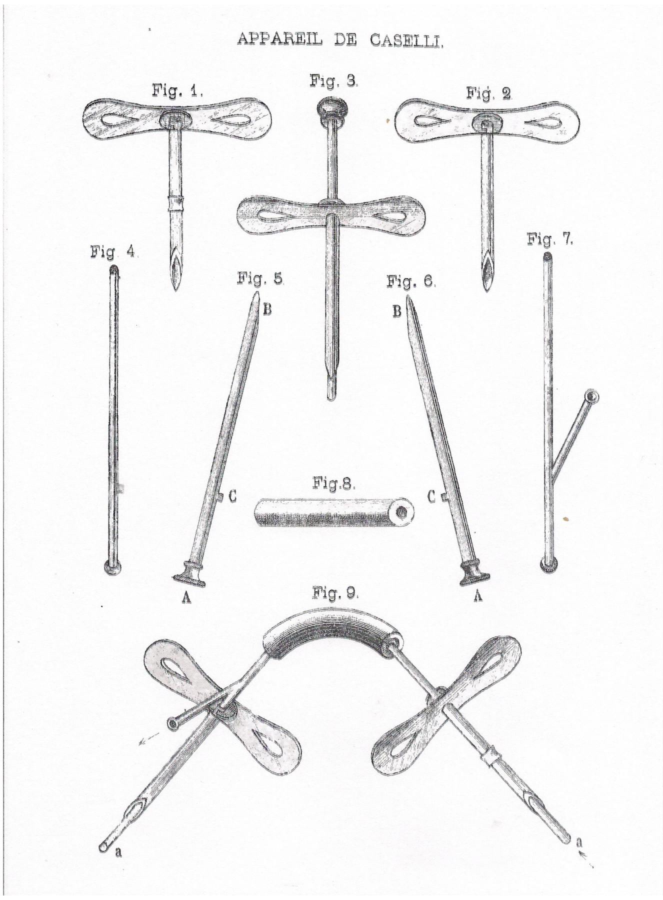


Luciani's apparatus (Plate 1, Fig. 4)

Caselli's instrument

Caselli's instrument for direct transfusion is far superior to other transfusion instruments. Here is the description given by its inventor:

"The instrument consists of two cannula needles (Plate 3, Figs. 1 and 2) cut into the shape of flute beaks, 5 centimetres long, equipped with two small ears to which a thread is fitted. Below the free end of the cannulas at the height of the ears, are placed two metal screens intended to receive the stopping point that protrudes on the two mandrels entering the cannula needles. These mandrels (Plate 3, Figs. 5 and 6) are finished on one end by a large button A and on the other by an inclined plane B like the end of the cannulas; but the tips are blunt and protrude beyond the sharp parts of the cannulas, to the point of making them blunt and harmless. The mandrels carry, not far from the button, a protrusion for a stop point C that adapts to the wire mesh found on the needle. Each cylinder has an engraved number on the button corresponding to the same number on the cannula needle screen. There are then two straight cannulas (Plate 3, Figs. 7 and 9; a, a/) of the same diameter as the mandrels, 8 centimetres long, joined by a small elastic rubber tube (Plate 3, Fig. 8), which does not exceed 3 centimetres in length. One of these cannulas is bifurcated in the shape of a Y (Plate 3, Fig. 7). The bifurcation branch comes off at an angle of 25° and at a distance of 2 centimetres from the insertion protrusion of the rubber tube. This second branch is 2 centimetres long."



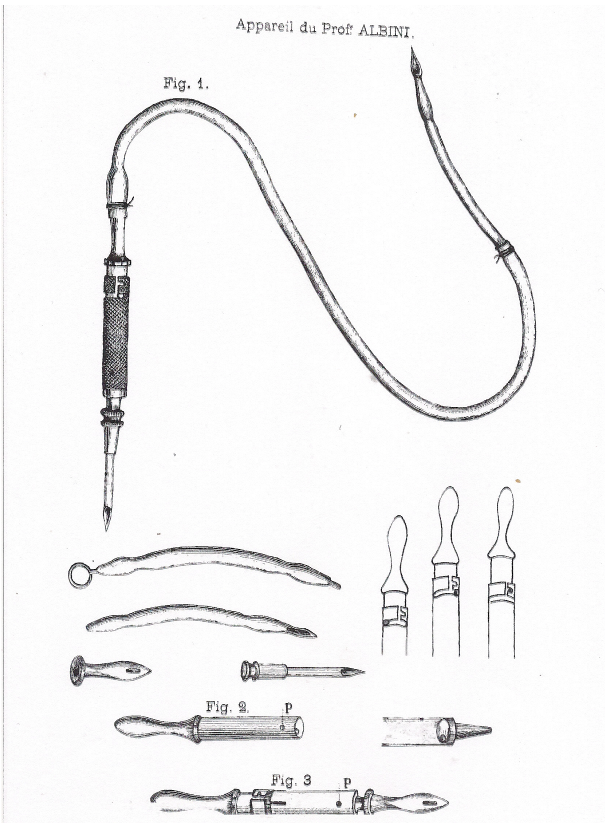
Caselli's apparatus (Plate 3)

How to use the instrument: The two needle-cannulas (Plate 3, Figs. 1 and 2) armed with their mandrels are introduced, one into the animal's artery, the other into the patient's vein. The mandrels are then removed and replaced by the two conduits (Plate 3, Figs. 4 and 7), the ends of which, exceeding the sharp part of the needle cannula, prevents the tip of the latter from injuring the internal membrane of the vessels. Once these conduits are fixed by their stopping point on the part of the cannula arranged for this, they are joined together by means of the rubber tube (Plate 3, Fig. 8). The Y-shaped duct is always placed in the vein of the transfused, the blood flow through the device is established from a to a$^{/}$ (Plate 3, Fig. 9).

Professor Albini's apparatus
(See: *La Trasfusione del sangue*, by Henrico Morselli, Torino, 1876, p. 321)

Professor Albini made two instruments (Plate 2) for practicing direct transfusion. The first is his 'hemodrometer' consisting of an elastic rubber tube, the lightness and thickness of which are proportionate to the vessels on which one operates, with a length of 40 to 50 centimetres. It carries at the ends two metal or glass cannulas, with olive-shaped ends: one is for the artery of the lamb, and is fixed there by a lace; the other is introduced into the patient's previously opened vein.

The second (1875) device (Plate 2, Fig. 1) is only a complication of the first. He added a very ingenious cannula which, when closed, prevents communication from the artery to the vein and lets out the first blood that might contain air; once opened, it establishes communication. It has two metal tubes, one of which is longer (Plate 2, Fig. 2) enters the second shorter (Plate 2, Fig. 3), each carrying a diaphragm with an eccentric hole at the same end, so that the two holes communicate only in a determined position. Another parietal hole lets blood escape (Plate 2, Figs. 2 and 3; P, P$^{/}$), and the holes are placed in such a way that when two of them communicate, the others, on the contrary, do not communicate. This instrument has the advantage of opening or closing the vascular communication, but it has the serious disadvantage of forcing the blood to pass through a narrow hole, of being complicated, and of leaving a wounding instrument in the vein.



Albini's apparatus (Plate 2)

In these various devices which are, in a way, only an artificial conduit established between the artery of the animal and the vein of the man, it is the cardiac pressure which determines the movement of the blood in the apparatus. This pressure, which is considerable, is amply sufficient to ensure this intermediate circulation.

Roussel's apparatus

In 1867, Professor Robin presented to the Academy of Medicine a direct transfusion device designed Dr. Roussel, of Geneva.

Description of the Roussel transfuser: To briefly explain its construction and technique, Mr. Roussel compares it to a new variety of leech, which would carry an accessory proboscis to the head to suck water before and during the sucking of blood, and whose forked tail would alternately launch water or pure blood through two lateral openings.

Like this leech, the transfuser is applied to the place it wants to bleed, by means of a suction cup in which neither water nor blood penetrates, which serves as an attachment point and forms an airtight sleeve around the mouth of the device.

This suction cup is activated by a special vacuum balloon. A rigid cylinder passes through the suction cup: its lower end surrounds the vein that is to be bled; its upper end is first opened and allows the designated vein to be seen very clearly.

This cylinder, representing the throat of the leech, is closed by the installation of the lancet holder, the animal's hidden tooth. The lancet is mounted on a slider that regulates its penetration; a very simple spring raises it after the puncture. The head of the lancet has two eyes that regulate the direction of the blade relative to the line of the vein.

The lancet plays, inside the apparatus, with a sharp blow struck on its head; then it goes up to hide in the top of the cylinder.

This hidden bleeding has been criticized a lot in advance, but still admitted after the study of the device. The direction and depth of the puncture are, I affirm, more exactly with the liking of the surgeon than in most conventional bleedings.

The puncture, made very quickly under hot water, by a heated blade, is hardly felt by the bleeding; it is always cured by first intention under a simple bandage in 8. [sic]

The tube, representing the accessory trunk of the leech, ends in the throat of the cylinder; it carries, at the other end, a bell which must plunge into a vessel full of water. This is the water suction tube. In the throat of the cylinder, the stomach of the animal, represented by an oval balloon, opens with two valves, suction and pressure pump, necessary for the transfusion.

Finally, the forked tail of the animal is a bifurcation carrying two cannulas of different calibres, controlled by a T-shaped valve, which alternately opens passage to the liquid through one or the other cannula.

This description is very inadequate. The figure (Plate 4, Fig. 2) will make understanding the transfuser a little better. If its construction is complicated for the manufacturer, its use is easy for the surgeon. [Note: The legend to this figure in the book appears in Plate 6 – PL]

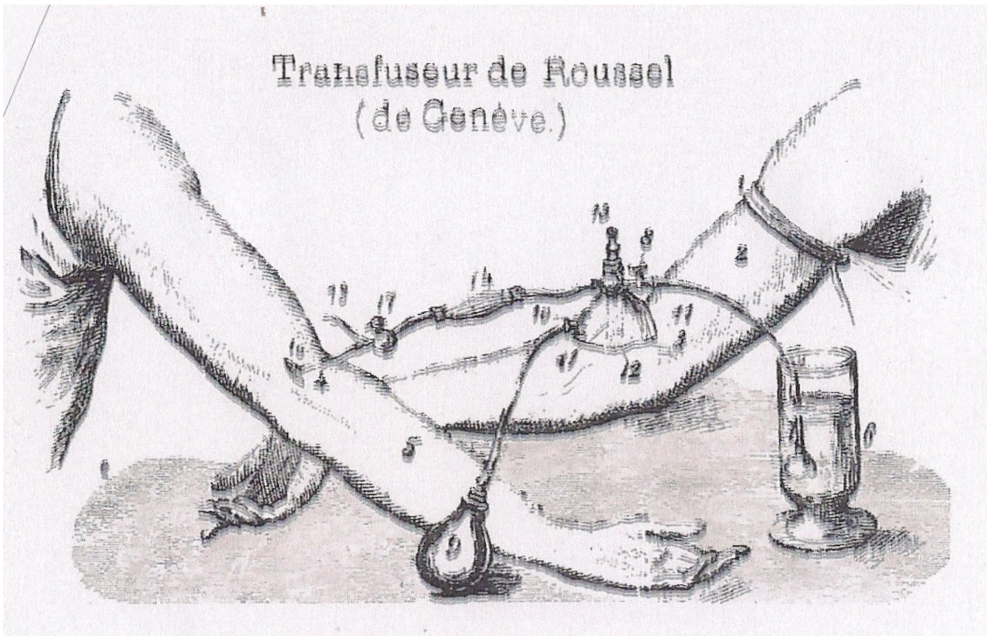
This apparatus has not had in France, says Mr. Jullien, all the success to which it was entitled: the complication of its mechanism is doubtless not unrelated to it; but, according to its author, it is unanimously adopted in Germany and Russia.

A Commission appointed to compare and judge the various devices, after numerous operations and experiments, presented a report on 19th January 1874 signed by Neudorfer, declaring "that the Roussel transfuser achieved the ideal of a practical apparatus for the direct transfusion of blood, and that it must be seriously introduced into the arsenal of military surgery."

Finally, quite recently, Mr. de Kosloff, the Medical Director of the Russian army, called for a competition of all the methods and all the transfusion devices, all of which were tested and comparatively judged; competition in which Gesellius, Heyfelder, Rautenberg, Korzeniewsky, Krassowsky, Kadé, Eichwald, Busch, Benezet, Froben, Pélikan, Rieter, Pilz, Hirch, Roussel and many others already familiar with transfusion, worked. Roussel's transfuser emerged victorious from the contest.

May I be allowed to express hope. Recently Mr. Roussel presented before the Academy of Medicine and the Society of Surgery the theory of his transfuser, which enabled him to obtain such remarkable and happy success.

The interest in his communication and to his important work on transfusion can give hope that after seeing the doors of Saint Petersburg and London open in front of his apparatus, the doors of Paris, to which he knocks for the second time, will also open.



Roussel's 'Transfuser' apparatus (Plate 4, Fig. 2)

Legend – Transfuser (Plate 6):

1. Band for bloodletting
2. Arm that gives blood
3. Turgid vein to bleed
4. Prepared injured vein
5. Arm that receives blood
6. Vessel containing water
7. Water vacuum cleaner bell
8. Valves closing the vacuum cleaner
9. Round ball of the suction cup
10. Outer casing of the suction cup
11. Internal cylinder of the suction cup
12. Lancet inside the cylinder
13. Lancet regulator slider
14. Transfusion pump balloon
15. Cannula introduced into the injured person
16. Bifurcation tap
17. Cannula rejecting water out

Devices for immediate transfusion under artificial pressure

When instead of immediate transfusion from artery to vein, it is done from vein to vein, the cardiac pressure, noticeably reduced, is barely felt; so there has been some thought of replacing it. It is to achieve this result that I have built one of my devices that will be discussed later.

Aveling's apparatus

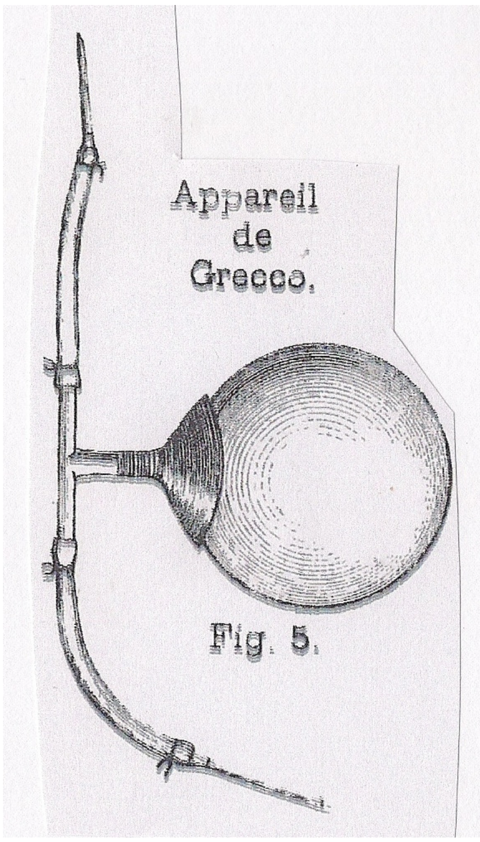
The apparatus of Aveling, of London, which is under artificial pressure, is composed of a central rubber pocket [bulb] terminated on each side by a tube of the same substance that adapts to the cannulas placed in the vessels.

The rubber pocket communicates freely with the tubes, so that in order to operate the apparatus, an assistant must compress the tubes alternately in front of and behind this pocket. It is understood that when this pocket is filled with blood, the pressure exerted on it with the hand will replace the ventricular systole.

Grecco's apparatus

Grecco's apparatus (Plate 1, Fig. 5) is none other than Aveling's modified as follows: The two tubes A and B are joined to a rubber receptacle O by a tube C which makes them communicate with each other.

It is enough to take a look at the apparatus to understand its mechanism; it is the same as that of Aveling. Its operation requires the fingers of two helpers, alternately compressing the blood inlet and outlet tubes, to the right and left of the rubber bulb.



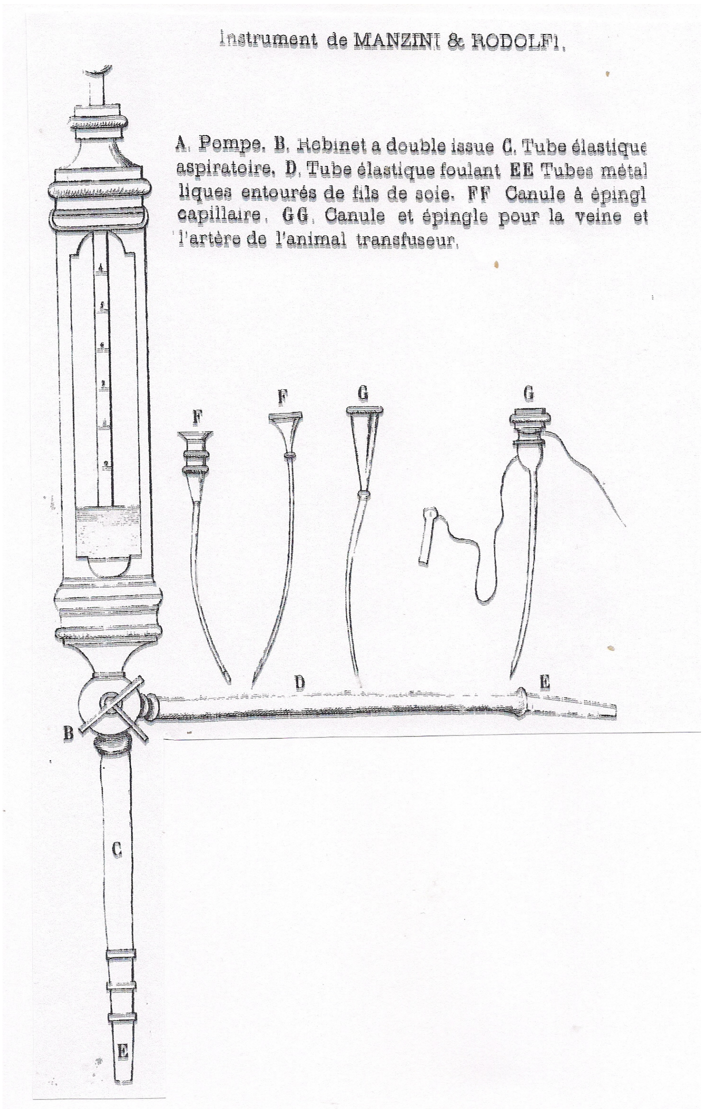
Grecco's apparatus (Plate 1, Fig. 5)

Manzini and Rodolfi's apparatus

This device (Plate 4, Fig. 1) consists of a pump body in which a piston slides. The pump body is articulated below with a nozzle from which two tubes emerge, one vertical and the other horizontal.

The first is intended to enter the vein of the animal that supplies the blood; the second, in the vein of the one who receives it. When the pump body is filled with blood, simply turn the tap, so that the opening that makes it communicate with the outlet tube is free. The plunger is then pressed, and the transfusion is done.

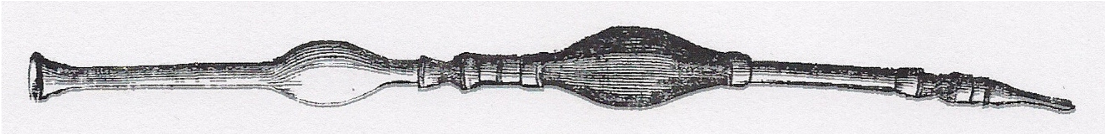
In order to avoid clotting, Manzini and Rodolfi take care to soak the tubes in an alkaline solution for twelve hours. This precaution is absolutely unnecessary.



Manzini and Rodolfi’s apparatus (Plate 4, Fig. 1)

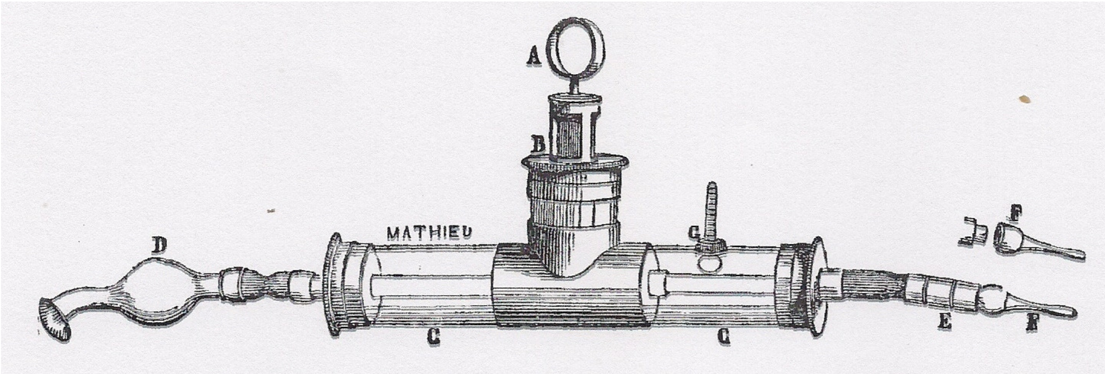
Moncoq's first device also uses artificial pressure. It will be discussed later.

Among the artificial suction devices, we must mention two imagined by Mr. Mathieu. The first one has a lot to do with Aveling's. The figure below sufficiently explains the mechanism and functions.



Mathieu's apparatus

The other, which dates back to 1863, is represented in the following drawing:

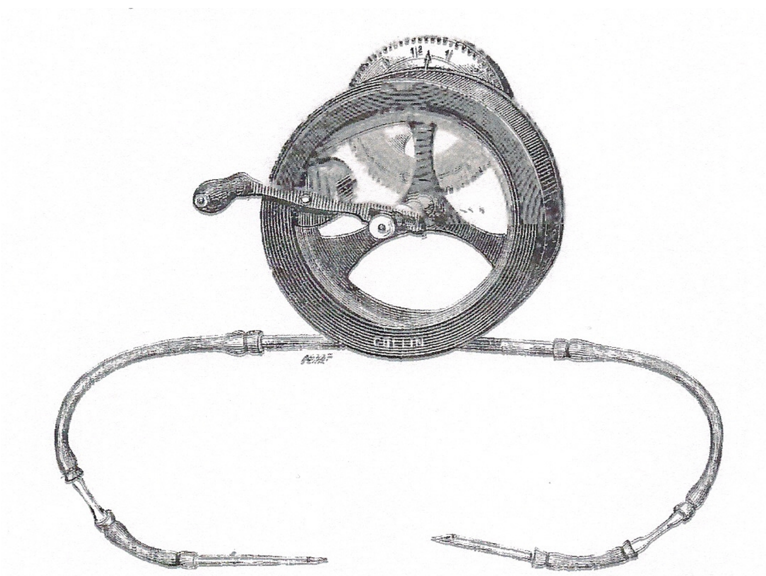


Mathieu's apparatus (1863)

It is easy to appreciate the mechanism. A pump body adapted perpendicularly to the middle of a glass tube is used to practice suction on one side, on the other the discharge. The glass tube is itself contained in a large sleeve that is filled with hot water.

Noel's apparatus

Another device, intended both to prevent the introduction of air and to give the exact measurement of the quantity of blood injected, is that which Mr. Collin built in 1874 on the instructions of Noel. It was presented to the Academy of Medicine by Mr. Broca on 13th July 1874.

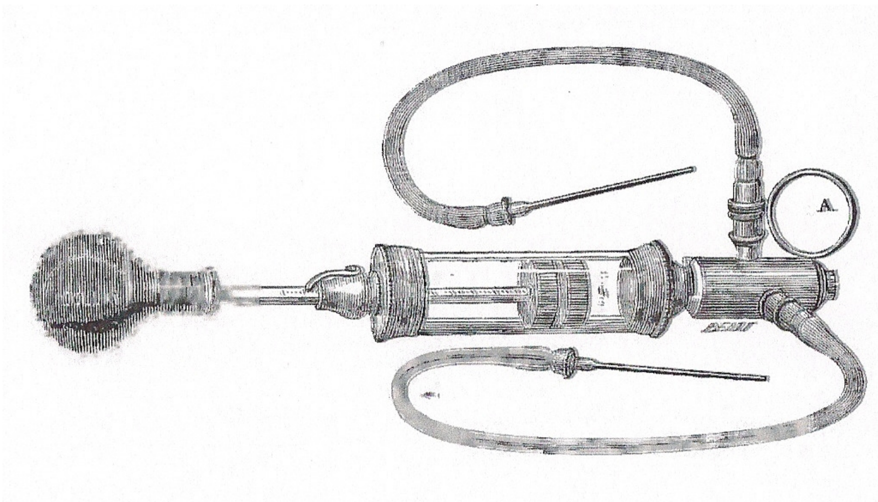


Noel's apparatus (built by Mr Collin)

It is a kind of suction and pressure pump, represented by a rubber tube making a complete turn inside a metal cylinder. A roller set in motion by a crank flattens this tube and determines both the suction and the discharge at the same time as a counter device indicates the quantity of liquid set in motion. This apparatus, certainly very ingenious, has not yet been used.

Collin's apparatus

Collin built three devices for transfusion. The first consists of a metal and glass pump body, controlling two needle tubes. These tubes are mounted on a cylindrical drum which serves as a reservoir and in which a metal ball replaces any valve and any external tap.



Collin's apparatus

Replace the drum of Collin's apparatus by a simple tap to which two tubes attach, we will have the Leblond transfuser.

SECOND CLASS - *Devices for mediate transfusion*

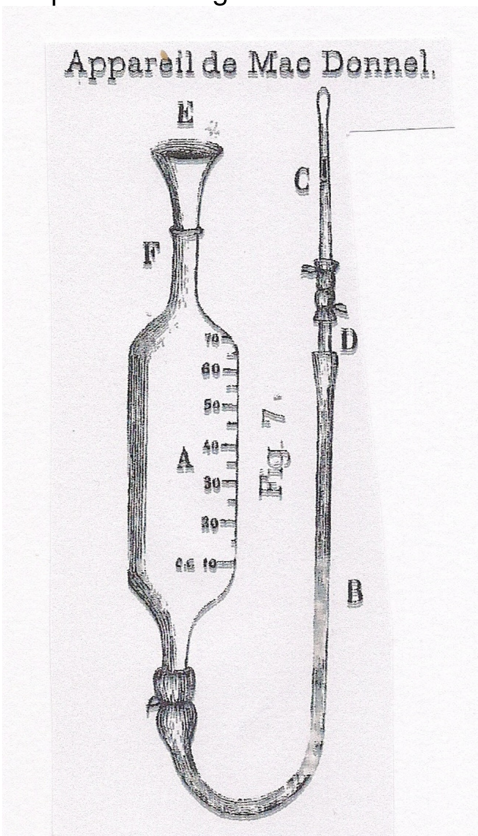
With these devices, the transfusion can be made by two methods:

1. With defibrinated blood
2. With whole blood.

Among the devices intended for transfusion with defibrinated blood, there are three that have some analogy between them. They are those of MacDonnel, J. Casse and Belina.

MacDonnel's apparatus

MacDonnel's instrument (Plate 1, Fig. 7) consists of a receptacle A of a known and graduated capacity; it is surmounted by a funnel E, into which the blood is poured. The rubber tube B carries a cannula C, which is introduced into the vein; the rubber tube is interrupted by a glass tube D, intended to allow the blood to be seen. When the defibrinated blood and the cannula are in place, raising the container the very weight of the liquid tends to push it through.



MacDonnel's apparatus (Plate 1, Fig. 7)

J. Casse's apparatus

J. Casse's apparatus offers a lot of analogy with the previous one.

I had the opportunity, at the time of the Brussels Congress (1875), to see the apparatus of J. Casse, and to hear this eminent colleague describe it himself. This device is very simple, very ingenious, easy to handle, but it can only be used for transfusion with defibrinated blood.

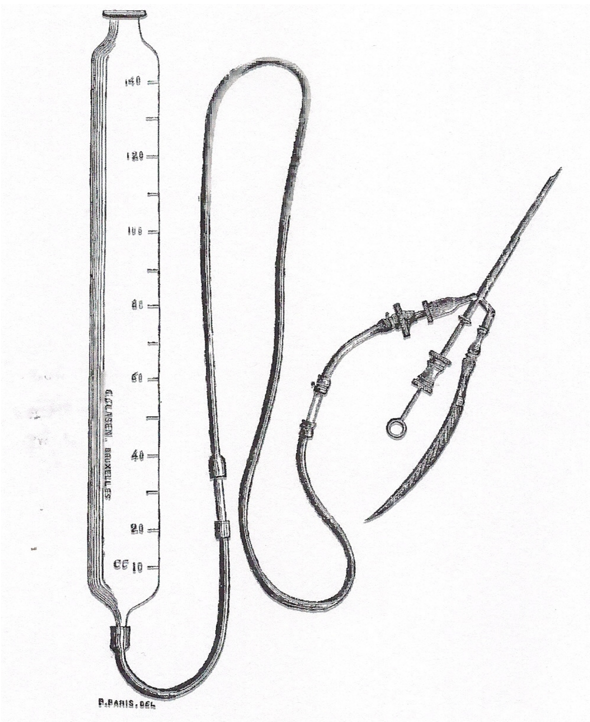
Starting from the physiological fact that the pressure in the veins being excessively low, only a minimal force is needed not only to balance it, but to easily overcome it (we know, in fact, that it is at most only 4 to 1, and that, to overcome it, a column whose pressure is equivalent to that quantity will suffice), by increasing the external pressure somewhat, the interior being overcome, the liquid enters the vessel. (This resistance is sometimes so low, that it only takes a difference in level of 10 to 20 centimetres to get the blood in with great ease.)

"To achieve these data", says Casse, "we composed our apparatus of an elongated cylindrical vessel, 30 centimetres in length, and graduated so as to allow the quantity of liquid introduced to be measured. Each of the ends of the container is narrowed. The upper opening, with a larger diameter than the lower one, allows the introduction of a funnel through which the blood, from the vessel which contains it, is poured into the receptacle.

At the other lower smaller end, fits a rubber tube 60 to 70 centimetres in length, the other end of which ends in a nozzle that in turn adapts to a cannula that is inserted into the vessel into which the transfusion is made (this device had already been described in the *Belgian medical press*, 13th May 1873.).

The blood can then pass directly from the container into the individual's veins; because, the apparatus being arranged as we have just said, the container filled with blood is raised somewhat, the normal internal venous pressure is overcome by the external pressure represented by the column of new blood that one wishes to transfuse, and the blood enters the vessels without shaking and in a continuous manner.

It is thus possible to introduce a more or less considerable quantity of blood. This quantity will be expressed by the graduation of the container. If, while the operation is being performed, any accident should occur and necessarily interrupt the transfusion for a longer or shorter time, the container would be lowered, and, the pressure no longer existing, the blood will stop flowing into the veins.



Casse's apparatus

If, on the contrary, we wanted to increase the pressure, it would suffice to raise the container further: the blood column rising and consequently the pressure becoming greater, the blood would flow with more energy into the veins. On the other hand, if we have taken care to ensure, beforehand, that there is no air in the tube, which we are certain at the time of fixing the nozzle we have seen the blood flow through the lower opening of the rubber tube, we will be convinced that the least amount of air could not have been introduced. In addition, to be perfectly sure of preventing this accident, it suffices to interpose on any point of the tube, but preferably near the cannula, a piece of glass tube serving as an index; the transparency of the material would allow the slightest passing air bubble to show itself, we would only have to undo the nozzle and let the blood flow, until the air bubble is out.

As can be seen, the apparatus which we use is extremely simple, inexpensive to construct, easy to handle, and capable of perfect cleaning. It facilitates the regular flow of blood, at the same time as it allows the pressure to be moderated at will, and finally gives all the guarantees for the non-introduction of air. In all of our experiments with defibrinated blood, we have never used any other device, and, as we have seen, we have injected enormous amounts of blood through it.

We have also used it with great success in the eight transfusions we have given to humans.

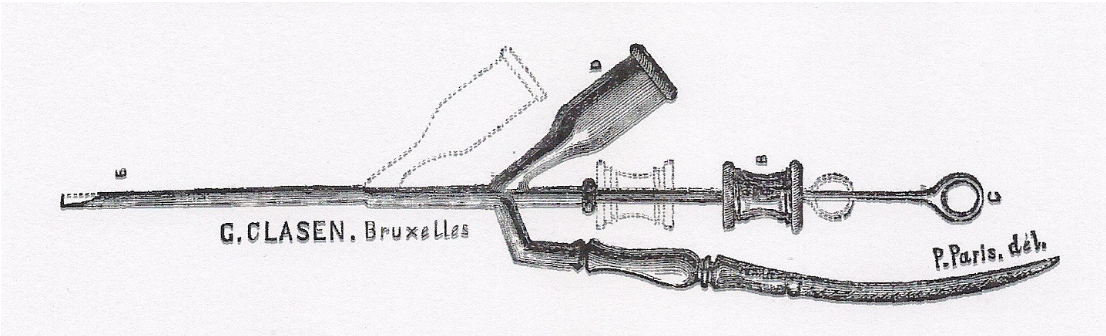
In a number of injections, we used a glass cannula whose olive end is bevelled and lightly edged, to avoid injuring the vascular wall.

There is a great advantage in using these cannulas, because they can be made very thin, so as to be able to introduce them into the smaller vessels, and they make it possible to see whether air is introduced. We may object to the fragility of the glass, but it is necessary to tighten a ligature very hand to break them; I would even say that in several trials we have never managed to do it.

Another advantage which results from their use is that owing to the small calibre of the cannula, any clot that may have formed would be fatally stopped. The simplest way for their introduction is to grasp the peripheral ligature of the vein, which, being thus stretched, allows to be easily punctured by a scalpel, and the plane of the bevel being put in the same direction as the section plane of the vessel, the cannula introduces itself, so to speak."

Sometimes it is difficult getting the cannulas in. To overcome it, Casse conceived an instrument that is the only one he uses today in transfusion on humans.

"It consists of a hollow needle E, fenestrated over part of its extent and terminated by a handle slightly bent at the end opposite the point. It contains a second tube B to which a nozzle D has been welded at an acute angle, which slides into the interior of the needle and into the opening left there. This nozzle is intended to receive the end of the device, and allows the blood contained therein to escape through the tube into the vessel where it is introduced. This same tube B is terminated by a box in which a mandrel C passes, with gentle friction, the length of the instrument.



J. Casse's cannula - needle

Now let's see the game [workings] of the device. The vein being exposed by an incision, the vessel is pricked by means of the needle, and this is introduced; as it would be difficult to make it penetrate sufficiently without risking injury to the vascular walls and perforating them, we slide the internal tube that then hides the tip of the needle and allows the instrument to enter at the desired distance. Once this is done, the mandrel which closes the internal opening of the nozzle is removed and blood passes easily from the apparatus into the vessel through the internal tube.

In this way, several advantages are obtained: (1) easy penetration into the vessel; (2) easy introduction of the instrument without injuring or perforating the vascular wall, something that is easily done by needles; (3) the possibility of stopping the flow of blood, if an accident occurs during the operation."

Belina's apparatus

"To practice blood transfusion", says Mr. de Belina, "various syringes have been used up to now, which only imperfectly meet the physiological conditions of this operation, namely:

1. That the apparatus can be kept in a state of perfect cleanliness.
2. That its capacity is sufficient to contain the necessary quantity of blood, and that it can be handled easily and with precision.
3. That it is possible to keep the blood at the desired temperature.
4. That the introduction of air bubbles into the vein be made impossible.

The syringes ordinarily used for transfusion consist of a glass cylinder fitted with accessories of metal or rubber and a plunger covered with greased leather. When fixing the accessory parts to the cylinder, there are always grooves between these parts.

In these grooves are always introduced dust, small pieces of putty, and especially blood, which is very difficult to remove completely; this blood breaks down and can infect the blood that will be used for a second transfusion.

Pistons are also, in the long run, very difficult to keep in a state of absolute cleanliness. Leather always absorbs a little blood; the fat becomes rancid, and from the leather of the plunger foreign matter is detached which easily spoils the blood and produces various pathological lesions in the lungs, such as embolisms and abscesses.

Several physiologists claim that the introduction of foreign bodies into the circulation could even be the starting point for the formation of tubers."

Mr. de Belina then criticizes Mathieu's device, which is more difficult to clean than most syringes, and then the gray rubber, which incessantly loses particles of sulphur that corrupt the blood.

Mr. de Belina believes that he has avoided all these inconveniences by constructing his device. Before describing it, let us dwell for a moment on the criticisms he addresses to the only two transfusion instruments of which he believes he should speak: Mathieu's instrument and the syringe.

He rejects them both for the reasons given above, and attributes most of the failures to the use of the syringe.

If we wanted to align ourselves as a supporter of the hydrocele syringe and argue that it allows for the practice of transfusion with all the desirable safety, we would find an unanswerable argument that would exempt us from providing any other in the many and indisputable successes that it has achieved.

Thus all the reproaches formulated by Mr. de Belina would vanish. Despite the grooves and the dust they contain, despite the blood that may have remained in the thickness of the leather, the rancid fat, etc., the ordinary syringe has cured many patients. The fears expressed by Mr. de Belina are therefore based on pure hypotheses that justify nothing and that the observation of the facts is reduced to nothing.

Besides, does the syringe not fulfil all the desirable conditions?

1. It is easy, if you want to take the trouble, to keep it in a perfect state of cleanliness.
2. Its capacity can have all the desirable dimensions.
3. It is, moreover, possible to keep the blood at the temperature that one deems suitable (we have shown by experimentation what one must think of the need to maintain the blood at a temperature equal to that of the body when performing the transfusion).
4. Finally, nothing is easier than to purge it of the air it contains

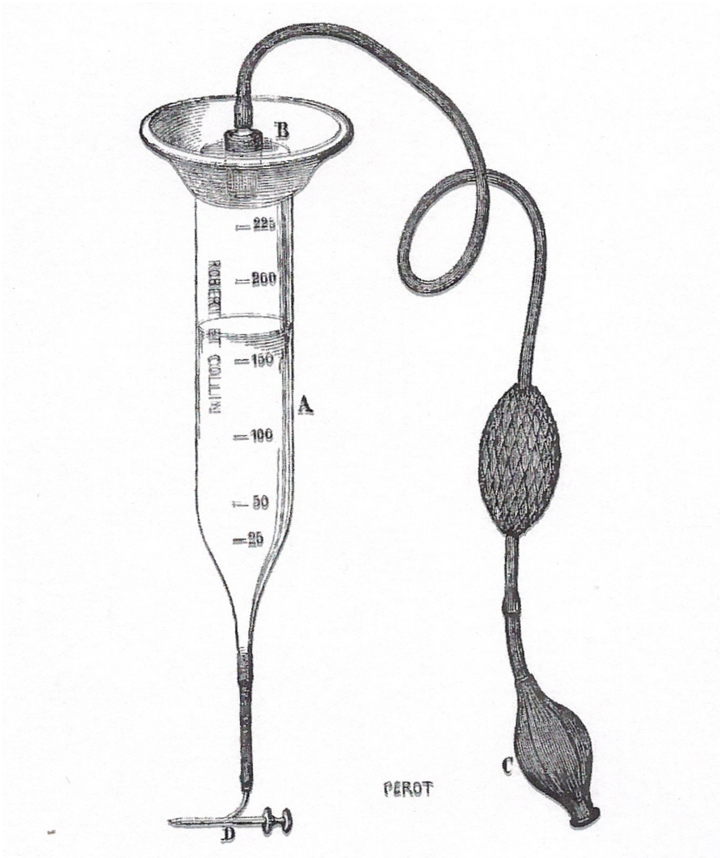
Does this mean that the syringe realizes for us the ideal of transfusion devices? This is not our thinking, since, like so many others we have sought to do better. We will see later what the motive is that drove us.

It is in the *Archives of Physiology* of 1870 that Mr. de Belina made his apparatus known; he reproduced the description of it in his thesis for the Doctorate of Medicine (1873).

However, before 1870, a transfusion apparatus had appeared. It had even made a lot of noise at the Faculty of Medicine in Paris and in the press: it is Moncoq's device. I have sought in vain for the simplest mention of it in the two Memoirs of Mr. de Belina! But let us come to the apparatus of Mr. de Belina, which he built to avoid the faults that he blames on others. What does it consist of?

Mr. de Belina believes that he has avoided all the inconveniences he points out in other devices by constructing the following one, which consists of:

1. An inverted cylindrical bottle A, 20 centimetres high by 5 centimetres in diameter. This bottle ends at the bottom with a neck 4 millimetres in diameter. At the top, constructed in the shape of a funnel, is a hole, B, 1 centimetre in diameter. This vial can hold 225 grams of blood, from zero to 225; above 225 remains room for air.
2. A compressed air pump C, consisting of two rubber balloons joined together and ending in a hose also made of rubber. This pump is constructed similarly to the Richardson Local Anaesthesia Machine.
3. A trocar, D, composed of two silver tubes and a stylet. The first pipe, 2 centimetres long, discharges, at an almost right angle with a slight inclination, into the other pipe, 5 centimetres long.



Belina's apparatus

The diameter of the two pipes is approximately 2 millimetres. The stylet, fitted with a small button-shaped handle, fits smoothly with the hose. The tip, triangular in shape, protrudes 5 millimetres from the opening of that pipe. At the opening of the trocar there is a spring that relaxes when the stylet is withdrawn, in a groove on the shaft, and in this way prevents it from being withdrawn further.

The three parts fit together as follows: the orifice B is filled with a perforated rubber stopper, which itself contains an ivory cannula protruding outward in the form of a button. This button is covered with thick gauze folded in half to stop dust and organic germs suspended in the air. On this button fits the end of the pump's rubber hose. The neck of the bottle is joined with the trocar tube ending in a button by a black rubber tube, 12 centimetres long by 4 centimetres in diameter.

In order to avoid too great a variation in the temperature of the blood, especially if one has to inject very slowly and if the temperature of the patient's room is not very high, the bottle may be fitted with a wool blanket; a cut-out has been made in it that allows the quantity of blood supplied to the patient to be seen on a metric scale engraved on the bottle.

The description of the device completed, here is how the transfusion will be performed. We start by defibrinating the blood using twisted glass rods; then it is filtered through a thick cloth and introduced through opening B into the bottle. The opening is closed with a black rubber stopper and the flask is placed in a water bath heated to 40°.

After bandaging the patient's arm as for a bloodletting, the median vein is discovered by making an incision one centimetre long. The bottle is removed from the water and dried; then, holding the neck, pull the rubber stopper down and insert the compression pump. The stylus is then withdrawn and all the air in the trocar tube is removed from the blood in the direction of the communication of the angle of the trocar, which is replaced in this way. When you are sure of this by seeing the blood flow through the opening of the tube, you must replace the stylet, wipe the trocar, have the bottle held in place by an assistant, and, after having fixed the vein with the left hand, insert the trocar into it, then withdraw the stylet.

The bandage is then removed from the arm; the trocar is maintained [in place] by the assistant; then taking the bottle with the left hand, we operate the compression pump with the right. Each pressure on the balloon brings about 20 to 30 grams of air into the space of the bottle above the blood level; the air is compressed inside and presses on the blood. By handling this balloon in a continuous manner and by regulating the flow of the blood by the introduction of the stylet, which can be used here as a tap, it will be possible to make the blood flow in the vein in a safe and uniform manner.

Professor Béhier has criticised Mr. de Belina's transfuser, which is so in keeping with my view that I am content to reproduce it as it appears in the *Revue des Cours Scientifique*:

"Mr. de Belina's apparatus is convenient and easy to handle, but presents this capital drawback that causes me to reject it: it is to have been built only able to be used for the transfusion of defibrinated blood. I believe I have sufficiently educated on the relative value of the use of intact blood and defibrinated blood, and the statistics that I am going to invoke later will only confirm this conviction. However, the device that allows the greatest safety and ease of the transfusion of non-defibrinated blood is, I repeat, the Moncoq-Mathieu device."

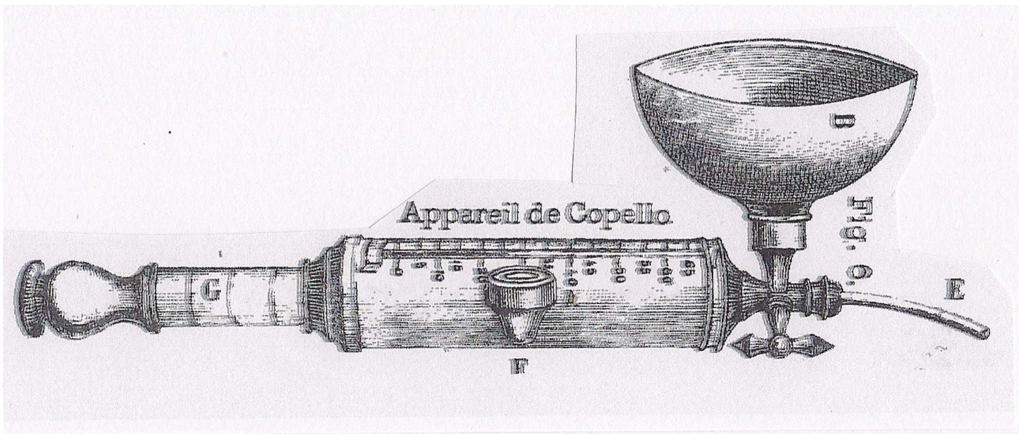
Mr. de Belina raises a certain number of objections against this apparatus, but which, to tell the truth, hardly seem to us to have any significance. This apparatus is, according to him, difficult to maintain in a sufficient state of cleanliness. This is not the case, believe it, and it suffices, before using it, to pass through it a certain quantity of slightly alcoholic lukewarm water to be quiet about it. "The vulcanized rubber," says Belina "lets out powdery particles that mix with the blood." This assertion is so strange that in truth I do not think it necessary to refute it. "The blood cools as it passes through the metal funnel and the pump body; it will therefore coagulate more quickly and by its contact will coagulate the blood contained in the vein where it is injected." This is absolutely not the case, as you have been able to see: moreover, by heating the device beforehand, by passing hot water through it, we protect ourselves from this cooling. Moreover, we know that blood has less tendency to coagulate the lower its temperature; the danger of refrigeration of the blood, assuming it does occur, is therefore quite negligible. Mr. de Belina adds that “all the operations carried out with Mr. Mathieu's device had no result other than the death of the patients”. Formulated in this way, this assertion, whose proofs are lacking for me, obviously appeared to me to be inaccurate.

At La Pilié, I had the opportunity to use the Moncoq-Mathieu device, with which I performed five successive transfusions on the same subject; he could not be saved, it is true, but this sad result took place in spite of the transfusion and not because of the imperfections of the apparatus employed. Besides, in any case, Mr. de Belina's assertion would not stand up to our new attempt, since the fact that you have witnessed constitutes a frank and brilliant success.”

I will add only a simple reflection to those above. When we ask in principle the superiority of defibrination blood, I do not understand that we can think of creating instruments that no longer respond to any indication. In such a case the ordinary syringe is by far the best instrument, as Mr. Brown Séquart has said.

Coppello's apparatus

Coppello's apparatus (Plate 1, Fig. 6) consists of an ordinary syringe A fitted with a funnel B, where the blood is received. The funnel is connected with the pump body by means of a pipe C with valve D. By turning the key in the direction indicated, the funnel is placed in communication with the syringe; by turning it, on the contrary, in the opposite direction, the pump body is placed in direct communication with the tube E, which serves to inject the blood. The pump body is further surrounded by a concentric vessel F, into which hot water is introduced to heat the device to the temperature that is believed to be suitable. A thermometer placed under the syringe is used to observe the temperature. The stem of the piston rod G is graduated.



Coppello’s apparatus (Plate 1, Fig. 6)

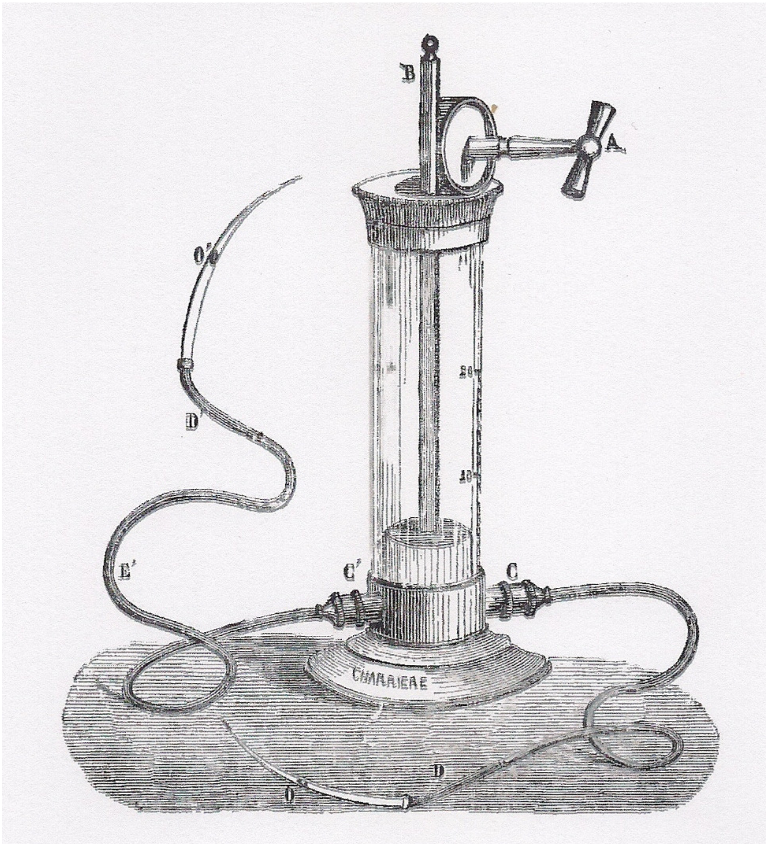
I will now talk about devices that can be used to practice both immediate and mediate transfusion: these are the devices from Moncoq, of Caen.

The *Moncoq Hematophore* inaugurated too important a period in the history of instruments intended to facilitate blood transfusion for me not to give it an important place in the description of the many devices that have been imagined and used in turn.

It was towards the beginning of 1862 that he asked Mr. Mathieu, manufacturer of surgical instruments, to make him the attached apparatus, to which he gave the name of Hematophore (avua, blood, pepo, I drive).

Moncoq’s device for immediate transfusion experiments in animals.

The goal of this apparatus was to connect, by an uninterrupted current, a plethoric subject intended to supply the blood and an anaemic subject intended to receive it.



Moncoq’s Hematophore (animal transfusion)

Legend – Hematophore:

A	Handle to set rod B in motion. (The middle part of the cylinder is made of glass; it is graduated in grams and has a capacity of 30 grams.)
B	Piston rod intended to alternate diastole and systole in the cylinder: this rod has a graduated rack and leaves it easy for the operator to direct the passage of the liquid, both for speed and for quantity.
$C^{/}$	Valve opening from outside-inside of the cylinder at the time of diastole.
$E^{/}D^{/}$	Tube used for the arrival of blood.
$O^{/}$	Opening on the convex part of the needle for the entry of blood into a channel.
C	Valve opening from inside-outside of the cylinder at the time of systole.
O	Opening on the convex part of the needle for the outflow of blood out of its channel.

Note. The needles $D^{/}O^{/}$ and DO have a much more pronounced curvature than in this drawing. The box containing the device also contains two straight channelled replacement needles, which are not shown here, and two channelled needles with their mandrels, able to admit the previous two in their gauge.

This device, in fact, provides the means of establishing this blood current between two subjects, one of whom needs to receive blood that the first can provide.

The theory of this device is quite physical: the middle part of this intermediate circulation instrument is a small graduated glass cylinder, playing the role of an artificial ventricle, in which a full piston forms systole and diastole by its alternative elevation and descent movements: you can graduate the piston rod, instead of graduating the glass, which is easier.

Two small, very sensitive valves $CC^{/}$ placed in opposite directions on the lower part of the artificial ventricle serve to direct the blood flow. A rubber capillary tube, 15 to 20 centimetres long, ends at these valves. Each capillary tube is terminated by a curved silver needle, a channelled [grooved] needle and bearing on its convex part, 15 millimetres from its point, an opening that completes the channel with which it is pierced: the complete apparatus is provided with spare straight needles.

The blood in the vessels being perfectly liquid, if its instant contact with the unorganized [sic] tube does not coagulate it, it should pass through the apparatus according to the physical laws of ordinary liquids.

Now, here is how, in the author's mind, the apparatus should function: given two animals immobilized for the transfusion, the vein of the animal that is to receive the blood is pricked with the needle DO, so that the opening O of the canal that it carries on its convex face, after having crossed the vein at two points, comes out, the point of the needle directed towards the heart.

With the second needle $D^{/}O^{/}$, the vein of the animal which is to give blood is pricked in a similar way, with the difference that the opening $O^{/}$ of the needle $D^{/}$ is in the very centre of the vein and plunges into the blood stream, the point facing away from the heart.

The two needles being thus arranged, if one makes the diastole in the glass cylinder by raising the piston B, the first effect of the vacuum that one produces is to open from outside to inside the valve $C^{/}$, which is pressed first by a few air bubbles contained in the tube, and immediately by the blood which flows from $O^{/}$.

If the systole is then made by lowering the piston, the blood and air are expelled from the ventricle in CD, and everything exits through the opening O of the second needle. From then on all the air is expelled from the apparatus, and by bringing the opening of this second needle back to the centre of the vein that is to receive the blood, the current is established, and it only remains to operate the ventricle, each systole of which drives out a wave of blood proportional to the movement imparted to the piston, a wave of blood that can be evaluated by the graduation in grams of the glass cylinder.

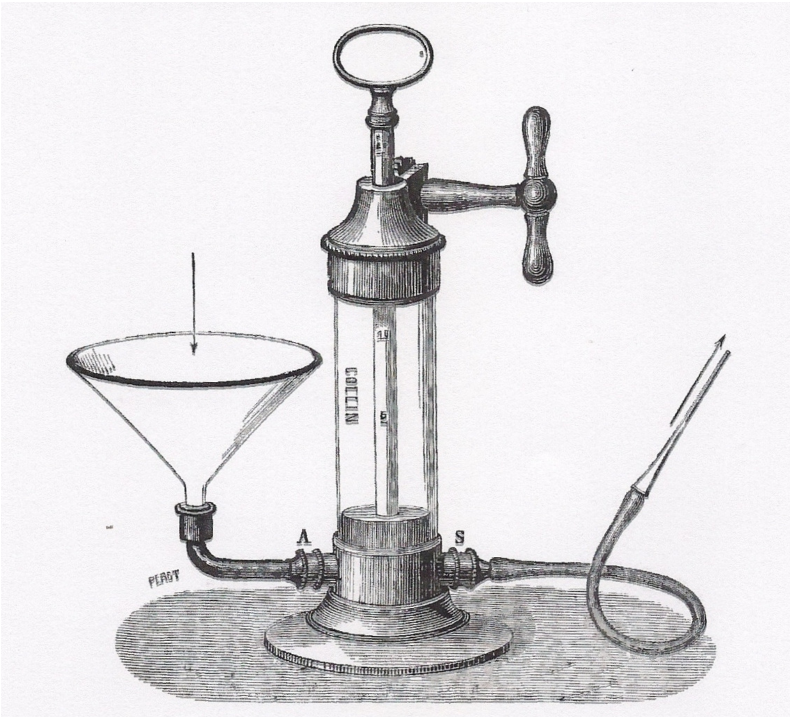
With this device, Moncoq was able to perform a large number of immediate transfusions on animals. All his experiments were checked by Mr. Bouley and succeeded perfectly. We have not forgotten the impact of blood transfusion made by Longet in 1863, in the large amphitheatre of the Faculty of Medicine. The account of this experiment carried out with the Hematophore was repeated by all the medical press of the time. Was what Moncoq had done for animals applicable to humans?

"As early as 1863, after my various experiments in animals, I understood," says Moncoq, "that the previous apparatus had to be modified for the transfusion of blood in humans, the goal of my research. I had learned, and we saw it at the beginning of this work (page 49), in the study of veins, that the operations carried out on these vessels required certain precautions not to expose them to phlebitis."

"I understood therefore that any man would easily give a little blood to save another man; but that it was necessary to remove all danger from the generous man disposed to this sacrifice. In an animal it is possible, without inconvenience, for a physiological experiment, to insert a fine canaliculated needle into the vein that is to give blood. But in a healthy man, apart from the fact that this operation would be painful, it would not be without danger: it would expose him to phlebitis.

Also, in order to remove any fear of phlebitis in healthy men who donated blood, I had a mediated transfusion device for humans built in 1863. This device is, as we will see, only a modification of the previous device. The exit tube and needle remain the same. There is also no difference in the middle part, in the intermediate glass heart to the two subjects, which, it can be said, is the important part of the device. There is only a difference in the way the blood enters the glass heart, in the middle part.

To realize this, we just have to take a look at the figure below.



Moncoq's modified apparatus – human mediate transfusion

The funnel, which is intended to receive the blood to be transfused, should be made of a slightly strong glass. It is understood that the blood will trickle down in this funnel, and that a small quantity will be needed to fill the bottom of this vessel. This funnel is also perfectly transparent; it is easy to judge the level of the blood and its perfect liquidity.

Its entry through valve A into the glass heart is done in the same way as in the apparatus that we have described above, by making the diastole by the elevation of the piston. The outflow of blood is also done in the same way, doing systole by lowering the piston. The first systole has the effect of expelling the air through the outlet valve S, and soon through the needle. As soon as the liquid comes out of the needle, the device is primed and filled with liquid.

The piston rod is also graduated, and always the blood to be weighed as it passes. Looking at this apparatus, it is easy to see the advantages it presents for mediate transfusion; it is important to support these considerations:

1. Blood, falling into a net into the bottom of a narrow funnel at its base, little is needed outside its own vessels.
2. The introduction of air is impossible in the vein of the subject who receives the blood, because the operator judges perfectly the liquid level in the lateral funnel and can stop when he wants, and also because the graduated piston has never

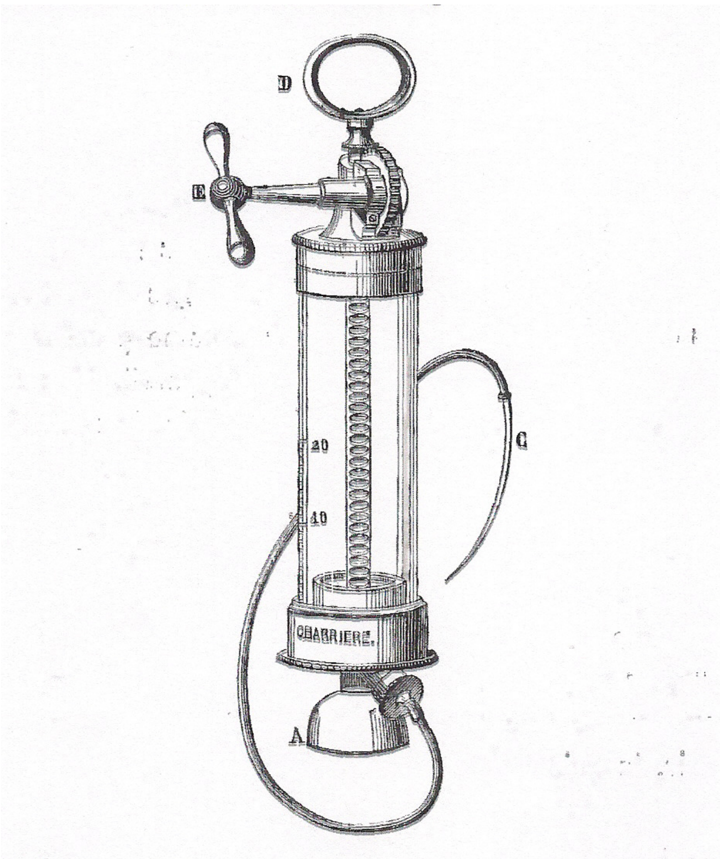
descended to the bottom of the crystal cylinder. We advise the operator to leave a layer of liquid blood below the piston, not lowering this piston to the bottom of the cylinder at each systole, so that, if by chance a little air had entered the cylinder, this air, by virtue of its specific density, would occupy the underside of the piston, but would not be driven into the vein of the subject receiving the blood.

3. Finally, this lateral funnel device, with the preceding advantages, which is immense, also joins this one; is that the distance between the two subjects can be very short.

Consequently we have two great advantages desirable for a good transfusion: we certainly avoid the introduction of air by the way in which we operate the piston, which is not completely lowered; and coagulation of the blood is avoided by the short path that separates the inlet of the blood from its outlet of the apparatus, by the instantaneousness of the passage.

The lateral funnel device can be used, says Moncoq, not only for mediate transfusion, but also for intravenous injections, which now seem to play a certain role in medicine. Transfusion of blood with the lateral funnel device is nothing more than an intravenous injection. The graduation of the device and its easy handling can make it a valuable instrument for this special purpose.

In 1863, after having established this apparatus for mediate transfusion, I thought that immediate transfusion in humans was possible, with a simple modification to the previous device. The body of the apparatus and the blood outlet tube remaining the same, I arranged an instrument carrying, at its lower part, a small transparent glass cup, for the introduction of blood.



Moncoq's modified apparatus – human immediate transfusion

"Modification of my previous device, allowing immediate transfusion in humans, with the maximum approximation of the two subjects:

A Crystal cup which is applied to the puncture made to the subject giving the blood and that should not press on this puncture.

S Tube and needle to drive the blood into the vein that is to receive it. The device carries, like the previous one, an inlet valve placed at the junction of the crystal cup and the transparent cylinder. It is very important that this valve, opening from bottom to top, is of very good mobility for the entry of blood. There is S-shaped outlet valve opening from inside to outside, in the opposite direction to the previous one.

This device, like the previous one, was built by Mr. Collin, successor to Mr. Charrière, in Paris. I do not know that it has yet been used by anyone other than me."

Here, moreover, is how to proceed with this device for immediate transfusion. The mode of entry of the blood into the anaemic subject and the position to be given to the two arms intended to be brought into contact do not change; they are only closer to each other. The two arms of the two subjects having been arranged as previously by a preliminary ligature, and the apparatus, well in order, having received a current of lukewarm water, the mandrel filled with its needle is introduced into the anaemic arm after the preliminary puncture .

A large puncture is made, as for a large bleeding, in the anaemic subject [sic – this is I believe a misprint and should be the plethoric subject, i.e. the blood donor – PL]. This large opening, as we know, is no more dangerous than a small one. The operator, using the left thumb, exerts pressure on the punctured vein that prevents blood from gushing out, until the transparent cup of the instrument is on the puncture itself.

We must not forget that, by the fact of the ligature, the plethoric arm represents a too full vessel, with elastic walls. So, and experience shows it to us every day in a good ordinary bloodletting, the blood of the plethoric arm asks only to come out, and to enter by the cup into the glass cylinder, representing a heart between the two subjects. By raising the piston, which is the diastole of this artificial heart, the blood enters it on its own, and also by the vacuum made when the piston is gently raised. By lowering the piston, the air is expelled from the apparatus, and the flow can therefore be established and continued between the two subjects, as before.

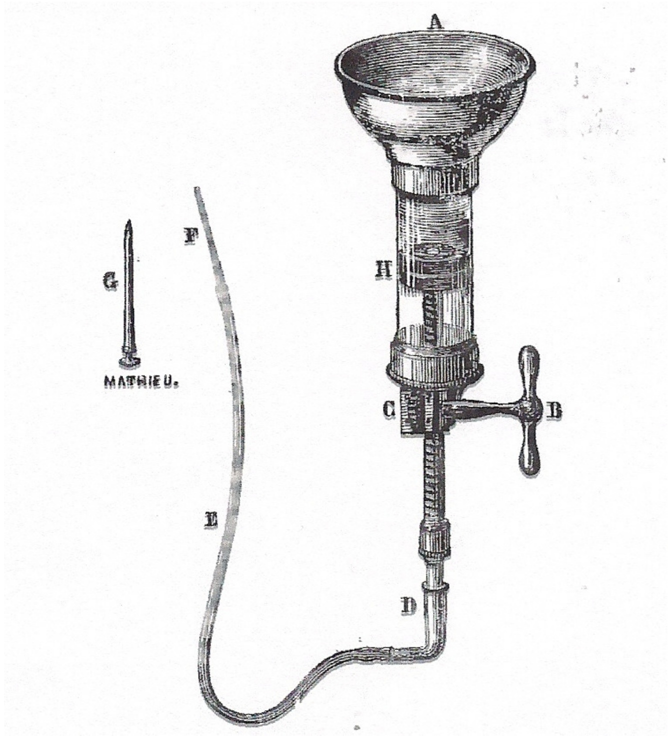
This device with a lower cup is, according to Moncoq, the solution for immediate transfusion in humans.

But is it better for the operator than the side funnel device? Here, he adds, is what he says to be the truth: "We can do the transfusion with it in the air. A more living blood is passed, if it is still possible, than with the preceding apparatus, because the flow between the two subjects is shorter, and the blood is taken at every moment at its source, into the living vessel which supplies it as it passes. But an operator, who was not trained in advance, would succeed sooner and more easily with the side funnel device."

I believe Moncoq is right. This apparatus does not appear to me to be easy to handle, and I do not believe that the entry of the blood into the crystal reservoir is as complete or as well assured as he seems to assert. I remain convinced that if the author himself had to perform a blood transfusion, he would prefer his device with the lateral funnel to the latter.

I do not intend to recall the discussion which arose between Moncoq and Mr. Mathieu on a question of priority: I am content to say that the Academy of Sciences has ruled in favour of the doctor from Caen.

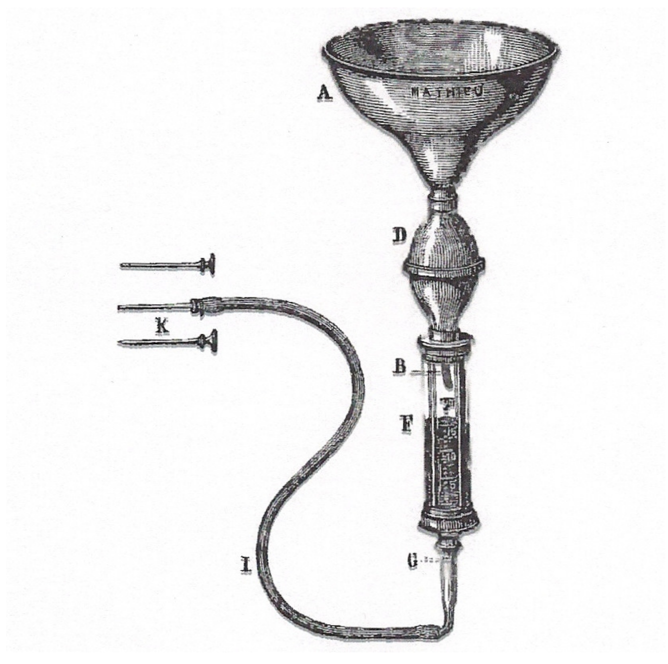
A year after Moncoq released his last device Mr. Mathieu built a new one. It consists of an inverted pump body H surmounted by a funnel A; at the lower part, the piston, perforated throughout its length, communicates to an elastic tube E, carrying at its end a small nozzle F intended to penetrate into the cannula of the small trocar G, which is previously placed in the vein. (Fig. 1)



Mathieu's apparatus (Fig. 1)

The use of this device is easy to understand. The supplied blood is received in the funnel; by making the piston move by means of the key B, it is driven into the pump body and naturally passes through the hollow rod of the piston to arrive at the cannula F in the vein of the recipient.

We would dwell more on the imperfections of this apparatus, if its inventor had not very recently replaced it by another. (Fig. 2)



Mathieu's apparatus (Fig. 2)

The latter is a combination of Mathieu's first device and the previous one. The piston is replaced by an ingenious mechanism, a rubber ball, which by a valve system, causes blood from the funnel A to pass through the pump body F. When the quantity of blood collected in the funnel is exhausted, the tube B, fitted with reed valves, gives a characteristic warning whistle.

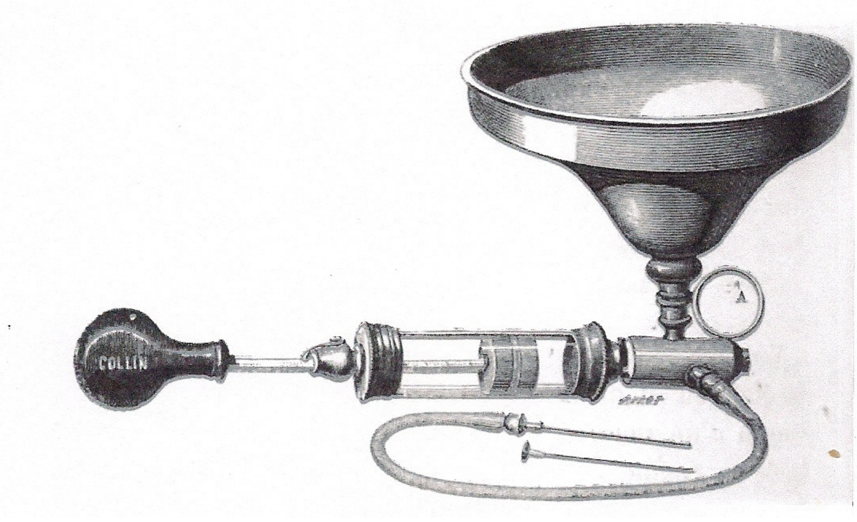
The mechanism of this device, very simple in theory, would be much less so in practice. This criticism, the only one I want to make of it, summarises all those that we could address to it.

The instruments built by Mr. Collin seem to us to be immune from this kind of reproach. (Fig. 3) The first model, adopted by the Medical Corps for the service of the armed forces, is operated as follows:

1. Place the container under the bleeding of the person offering his blood.
2. Pass the index finger of the left hand through ring A.
3. With the bar bearing the inventor's name placed at the top, aspirate blood up to half of the pump body then drives it abruptly to make the air disappear.
4. The apparatus is filled by pulling the piston to the top of its stroke.
5. Twist the piston from left to right to close the inlet tube and open the outlet tube.
6. Gently push the plunger to pass the blood into the patient's arm.
7. Twist the piston from right to left (in the opposite direction to the first) to put the pump body back in communication with the receptacle and allow suction again.

This manoeuvre should be continued until the quantity of blood injected is considered sufficient. The pump body contains 10 grams of liquid.

A spring attached to the manual end of the pump body holds the piston when pulled and then, when pushed, to prevent wrong manoeuvres.



Mathieu-Collin’s apparatus (Fig. 3)

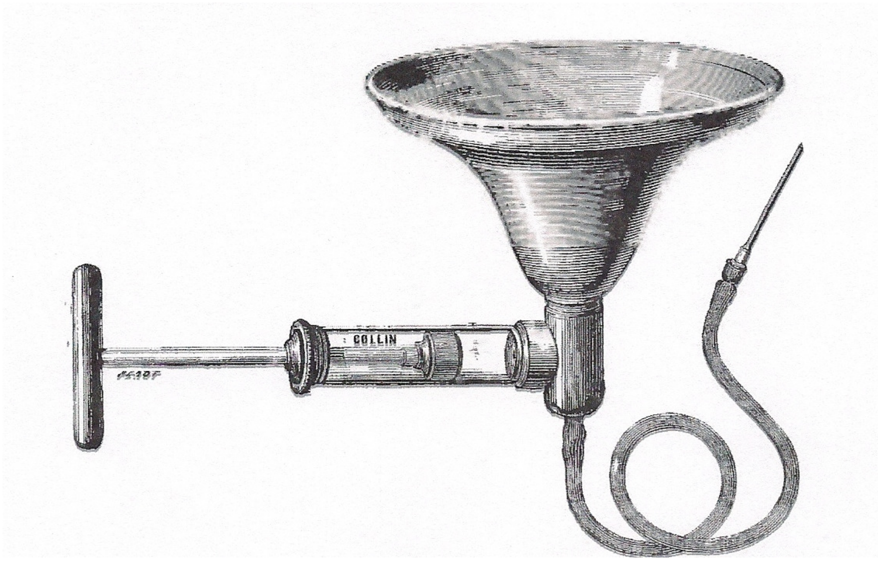
To put the device in communication with the patient's arm:

1. The instrument’s trocar is inserted, from the bottom up, into the vein.
2. The sharp stem of the trocar is withdrawn and replaced by a blunt rod that forms a tip with the cannula and allows the latter to penetrate more deeply without damaging the walls of the vein.
3. The rubber tube being purged of air, the cannula at its end is placed in that of the trocar, where it tightly fits; then, following the instructions given above, the transfusion is performed.

Arm-to-arm transfusion can be done with this device by replacing the container with a second rubber tube.

This device works without taps and valves, which are sometimes unfaithful in the middle of an operation, and which, in any case, one is obliged to change for each transfusion; being constructed of metal and glass, it can last a great number of years without deteriorating.

Mr. Collin's second model consists of: 1) a bowl; 2) a pump body; 3) a distribution chamber; 4) a tube; 5) a trocar. (Fig. 4).



Mr. Collin’s second apparatus (Fig. 4)

The bowl, with a capacity of about 300 grams of blood, has the shape of a flared funnel, with moulded and rounded walls: the depth is 10½ centimetres, the widest diameter 15 centimetres. It is made of thin nickel-plated metal; it is this that the operator's left hand seizes; so that the blood it contains is not exposed to any oscillations that could cause or activate coagulation.

The pump body is built under conditions of exceptional simplicity. It is a regularly calibrated glass tube 8 centimetres long, equipped at both ends with two metal frames that ensure its strength and which are not under any circumstance in contact with blood. Its outer circumference is 8 centimetres. Its capacity is exactly 10 cubic centimetres. The piston, also very simple, full, with gentle friction in the pump body, is constructed so as to present the blood liquid with a perfectly regular surface.

Distribution chamber: The blood is sucked from the bowl into the pump, and pushed back from the pump into the tube without having to undergo contact with any valve. Experience has shown that any tap or valve, by multiplying the contact surfaces and presenting to the blood edges and ridges, has the effect of producing blood coagulation. The purpose of the distribution chamber is precisely to make this cause of coagulation impossible. It is made up of a cylindrical space located in the continuation of the axis of the bowl, and communicating by three equal openings with the bowl, the pump and the transfusion tube; it contains a spherical, regular, hard rubber, or hollow aluminium ball, the density of which has been calculated and known to be less than the density of blood (1055).

This ball therefore floats on the blood in the chamber. When the piston is aspirated, the blood going down in the pump body moves it, but it immediately returns to its original position; during the stride, preventing the blood from entering the bowl; the blood can only follow the path of the transfusion tube.

This mechanism offers an advantage far more serious than that of simplicity: it makes the propulsion of air into the vein impossible, whatever one does. It is easy to understand that, since the ball only plays the role of a valve on the condition that it floats, as soon as the bowl, and consequently the distribution chamber, which is strictly speaking only the bottom, will be empty of blood, the ball will fall by itself in the lower part and will automatically apply to the opening of the transfusion tube. The pump will be able to suck in air, but it will push it back through the only free route: the opening of the bowl. The ball which, as long as the device was loaded with blood, prevented the flow of blood back into the bowl, prevents, as soon as the device is empty, the flow of air into the veins.

This result is obtained by the use of a more constant force than the tap and valves, an invariable force: gravity.

The tube and trocar are no different from those that were part of various models that were produced prior to this one.

This transfuser was presented to the Academy of Medicine (meeting of 8th December 1874) by Professor Béhier, with the following note, which we borrow from the reports:

"The transfusion operation presents two orders of dangers, the seriousness of which has hitherto hampered the attempts of doctors: 1) formation and projection of clots; 2) introduction of air into the veins; the first of these dangers seems to have been made impossible by the provision of the transfusion device that Mr. Collin presented six months ago to the Society of Surgery: the elimination of the valves and taps, the absence of rubber, made the operation easy and harmless, as experience elsewhere has shown. There remained the danger of the introduction of air; with attention, it was undoubtedly avoided. Mr. Collin has endeavoured to make these accidents independent of a false operative manoeuvre; the instrument he presents automatically prevents the introduction of air into the veins. The propelled blood fills an incessantly renewed chamber or reservoir; a float, made of unalterable substance, lowers as soon as the liquid is used up. This float, lighter than blood and heavier than air, remains above the expenditure tube and opposes the passage of air, which always escapes, no matter what one does, through the upper orifice."

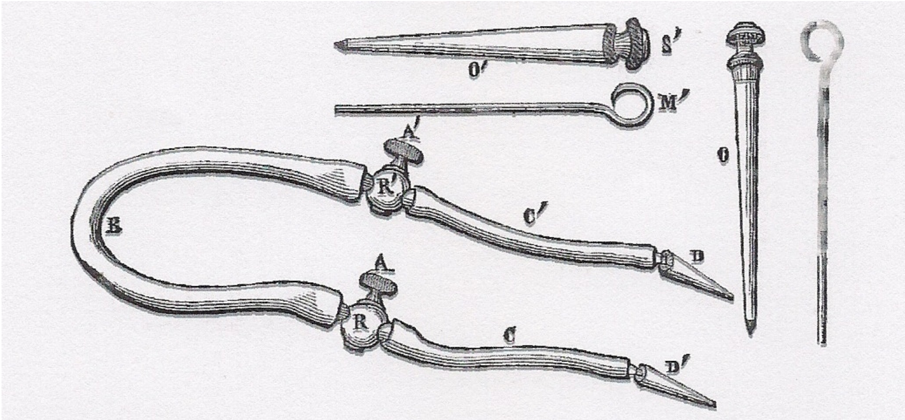
***My transfusion devices*.**

Since the time when I started my first studies on transfusion, I thought of creating devices intended to facilitate its execution. I was then using the hydrocele syringe, which is a very sufficient instrument when operating with defibrinated blood, but which has many drawbacks when transfusing with whole blood.

The most regrettable of all these disadvantages is the obligation of the surgeon to operate the instrument himself, an obligation that does not leave him the freedom of his hands to monitor, maintain and immobilize the cannula in the pricked vein. Then, by operating with the syringe, it is impossible to exert a uniform pressure on the plunger, so that the arrival of the blood in the heart is jerky, which is not without inconvenience, even without danger.

It is to remedy these defects that I have devised devices, the description of which will demonstrate that they can be used for both immediate and mediate transfusion.

My first device consists of a rubber tube B, at both ends of which there are two copper taps RR/ each fitted with a valve AA/, which can be opened and closed at will. A rubber tube CC/ is fitted to each tap, which ends in very tapered cannulas DD/. To complete this apparatus, I use: 1) two cannulas, OO/, crossed by three-quarter SS/ (arranged as for the three-quarter explorer): these two cannulas, armed with their three-quarters, are intended to prick the vein where the blood is to be injected, the other to prick the vein which is to supply it; 2) two mandrels MM/.

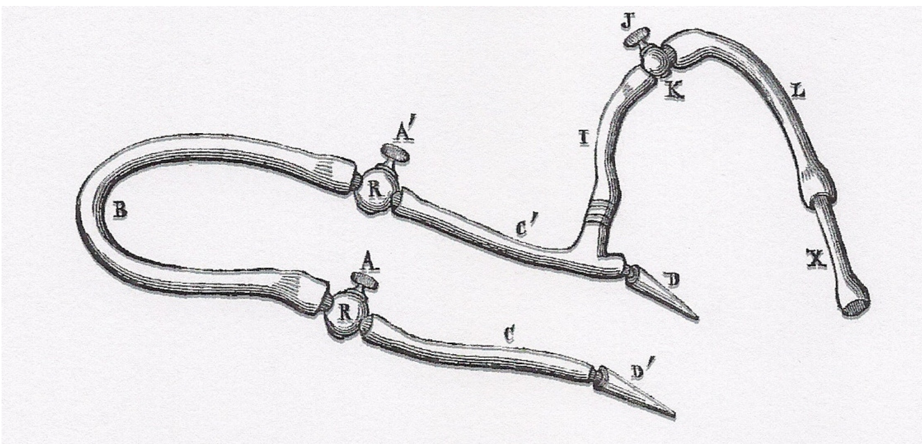


Oré’s apparatus #1

How to use the instrument: I start by pricking the two veins between which I want to establish the blood flow with the cannulas O and O' armed with their three-quarters. Once in place, I remove the three-quarters S and S', which I replace with the mandrels M and M'. The latter, ending in a rounded end, are less likely to injure the walls of the vessels. This done, I remove the mandrel M, placed in the vein that is to supply the blood, and replace it with the tapered cannula D. The valves A and A' being open, I create the suction in D. I thus purge the apparatus of the air it contains and the blood begins to flow. At this time, I put this last cannula D' in place of the mandrel M'. The two animals are thus in contact, and the blood of one passes directly into the other.

Although very simple, this device has done me great service. It allowed me: 1) to make immediate transfusion; 2) to prevent contact of the blood with the exterior air, and consequently to remove this cause of too rapid coagulation. However, it had one drawback due to the slowness with which the blood flowed through it. So I tried to modify it.

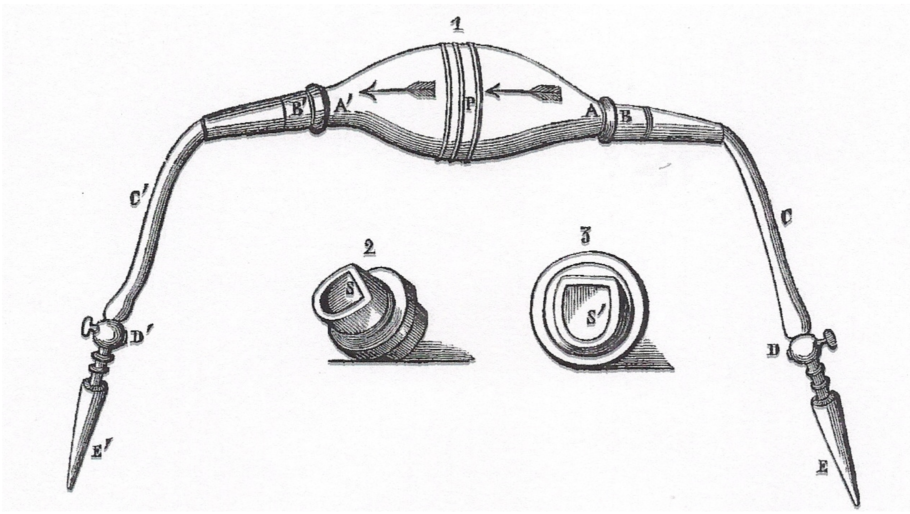
In the second device, which is an exact reproduction of the previous one, I placed an aspirator tube near the cannula that enters the vein of the animal I want to transfuse. It allowed me to create a vacuum, thereby causing the blood and accelerating its movement.



Oré’s apparatus #2

It offered me serious advantages, but nevertheless it still did not realize my expectations; so I replaced it with the following device, which worked in almost all my early experiences.

The third apparatus (Fig. 1) consists of a rubber pouch P, ovoid in shape, with walls strong enough to prevent it from collapsing under atmospheric pressure. To this pouch fit, on each side, two metal parts AB and $A^{/}B^{/}$, screwed one on the other and separated by a valve S and $S^{/}$ (Fig. 2 and Fig. 3). The valve which is placed in B opens from outside to inside; the valve at $B^{/}$ opens from the inside out, so that the liquid entering the apparatus through tube C, lifts the first, fills the pouch and passes into the tube $C^{/}$ by lifting the second valve. From this, it is easy to imagine that the two valves act in opposite directions. From the metal part B starts a rubber tube terminated by a copper tap D and a cannula E. The same arrangement exists on the opposite side.



Oré’s apparatus #3 (Figures 1, 2 and 3)

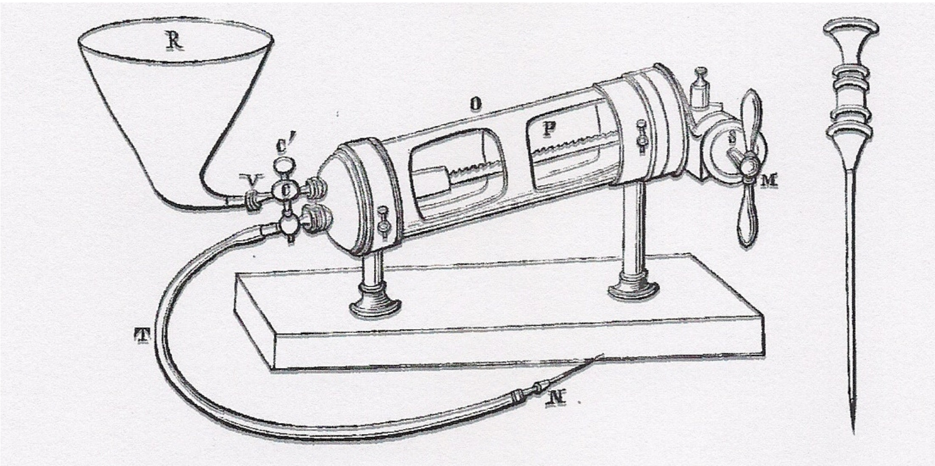
How to use it: After having opened the tap $D^{/}$, close tap D, and press on the pouch so as to expel through tube $C^{/}$ all the air it contains, which is stopped from returning into the device by immediately closing tap $D^{/}$. Then cannula E is placed in the vein of the animal which is to supply the blood. With tap D open, the blood rushes into the pouch, which it fills. The pressure exerted on it causes it to flow into tube $C^{/}$ terminated by the cannula $E^{/}$, introduced into the vein of the animal on which the transfusion will be operated. It is understandable that the valve which is in AB rises to let the blood arrive in P, but that the pressure exerted on the rubber bulb is enough to close this valve and prevent the liquid from returning into tube C.

Although this device then rendered me important services, especially for carrying out immediate transfusion on animals, I do not hesitate to recognize that I hastened to adopt Mr. Moncoq's device, as it seemed to me convenient, ingenious, and of a mechanism superior to any of my own. From that moment on, I used Moncoq’s device until the time when I had my fourth transfusion device built.

Moncoq's apparatus, which had made such great progress, nevertheless presented a defective aspect; it required too many helpers. The surgeon, obliged, in fact, to deal exclusively with the functioning of the device, is forced to entrust to a first helper the care of maintaining the cannula in the vein that receives the blood; a second is responsible for bleeding. In hospitals and in civil practice, nothing is easier than to surround yourself like this. But is it the same in the country, where the doctor is alone, far from all help, having only inexperienced people around him, and yet, called to a sick woman who is about to die of metrorrhagia, he must act without delay. However, so that the doctor placed in these exceptional conditions does not hesitate to operate, so that he can above all do so with confidence and safety, it is essential to put in his hands a device that will meet the following three conditions:

1. Charge alone and quickly with the blood that is to be injected into the vein.
2. Once filled, the device must empty itself. This condition is essential to allow the surgeon the free use of his hands. There are, in fact, two essential things in transfusion: 1) Keep the cannula through which the blood is to be introduced exactly in the vein. The operator should not entrust this care to a helper, because this is one of the stages of the operation on which success depends. 2) Of no less importance is the time of the arrival of blood in the vessel. The blood flow must be able to be slowed down or accelerated at will. The surgeon can easily fill this requirement if he is not obliged to empty the device himself, to act on a crank intended to lower the piston, or to compress and alternately release a rubber pouch.
3. Finally it can happen, despite all the precautions taken and all the desirable dexterity that foreign bodies from outside or quickly formed small coagula of fibrin, meet in the blood that is going to be transfused. Introduced into the circulatory torrent, they will cause accidents. We must therefore, by a particular arrangement of the apparatus, prevent this complication from occurring.

These are the conditions that I have sought to achieve in this fourth apparatus.



Oré’s apparatus #4

Let me say, first of all, that I could only arrive at the solution of the problem by borrowing this or that arrangement from already existing devices and associating them in such a way as to achieve the goal. This will emerge, moreover, from the description I am going to give of it.

Description of the device: It consists of a crystal pump body P; perfectly cylindrical with very thick walls that can contain 80 grams of blood (it is very rare that one is obliged to transfuse a higher dose). This inclined pump body, fixed on two copper rods falling perpendicularly on a board where they are screwed, is crossed at its front part by a graduated metal rod, which allows the operator to always know the quantity of blood injected. At the lower end of this pump body leads to two conduits provided with taps C and C′. To one of these conduits fits a funnel R intended to receive the blood; on the other, the rubber tube terminated by the cannula which leads it into the vein.

At the upper part of the pump body, there is a ratchet, I, intended to be placed in the gears of the piston, in order to stop it when it is deemed appropriate, that is to say that one wants to make it reach only part of its run, or that it is taken to the top of the pump body as a result of the movements imparted to the crank M.

Next to the crank and crossed by its axis, there is a box S containing a strong steel spring, which being in relation to the axis of the crank, aims to lower the piston without the surgeon having to intervene.

Finally, if we unscrew the conduit to which tap C is adapted, we will find a fine mechanical trellis there, which the transfused blood must pass through, before arriving in the vessel, and on which it will deposit all the foreign bodies that it can contain. I have recently been able to appreciate the usefulness of this sieve, either in the transfusion experiments on animals made in my physiology lessons at the Bordeaux School of Medicine, or in a transfusion performed on a man at the Saint-André hospital in Bordeaux.

It is enough to take a simple glance at this apparatus, to recognize, as I said above, the borrowings I made with instruments already known.

The funnel R recalls, by its arrangement, the one that Mr. Moncoq added to his second apparatus (1863); the inclined pump body with its graduated rod and its mechanism, is none other than Dieulafoy's remarkable vacuum cleaner; finally, the box S, containing a spring which imparts a downward movement to the piston rod, is the reproduction of that which surmounts Eguisier's irrigator.

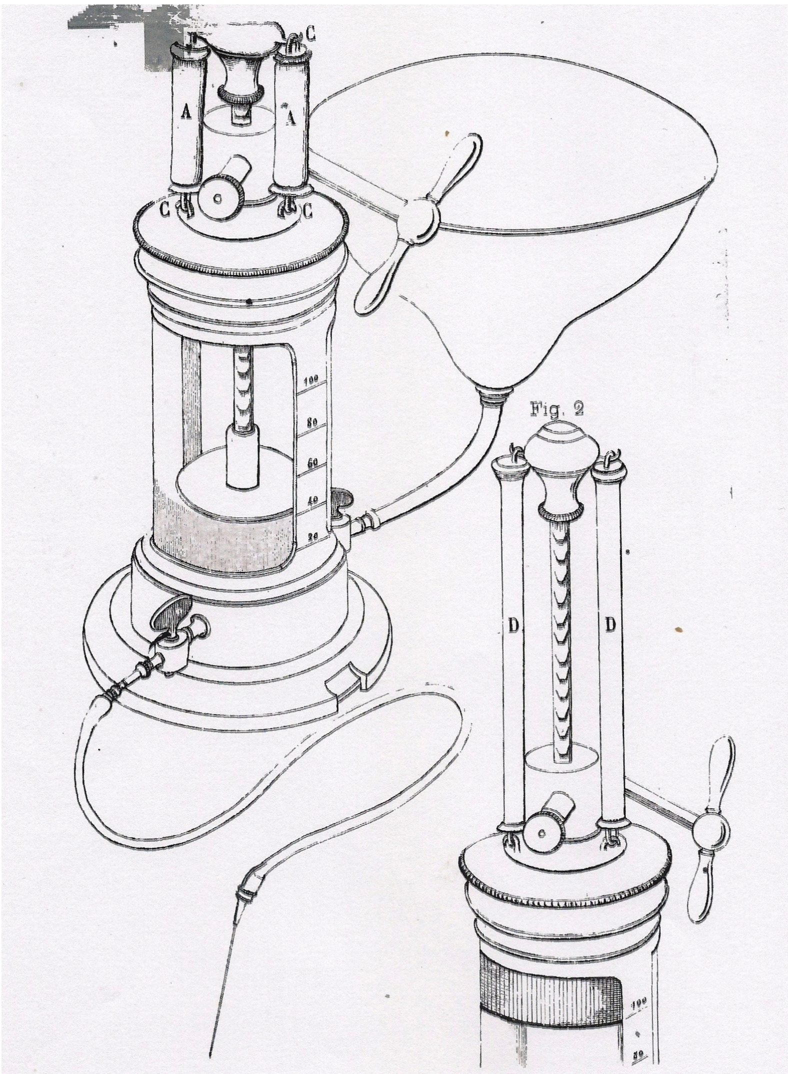
With all these loans put together and associated, as I have just said, I made an instrument with which the surgeon can alone, without any help, perform blood transfusion with the greatest ease. To prove it, it will suffice for me to describe its mechanism.

Mechanism of the device: The device, being placed on a table near the patient, one begins by purging it of the air that it contains. The CC/ valves being closed (they are closed when they occupy a position perpendicular to the direction of the ducts they surmount), a vacuum is created by making the piston go up to the top of the pump body; at this point , the ratchet, engaging in one of the rod's gears, immobilizes the piston.

Once the vacuum has been established, a capillary trocar surrounded by its cannula is inserted into the patient's vein, then a large bleeding is made to the person who is to provide the blood, which is collected in the reservoir R; then valve C/ is opened through which the blood rushes to instantly fill the pump body. This tap is immediately closed. After having articulated the rubber tube with the cannula, you open valve C: immediately the piston goes down by itself, driving the blood into the patient's vein. The surgeon, thus with his two hands free, will fix the cannula placed in the vessel with one; with the other, depending on the degree of opening given to the tap, it will slow down or accelerate the movement of the blood at will. When he wants to stop it altogether, he will only have to turn off this tap. The surgeon will therefore be able with this instrument, the mechanism of which differs from all the others, to perform the transfusion alone, without the aid of any assistance.

Gendron's apparatus

Dr Gendron's device (Plate 5, Figs. 1 and 2) was built to fulfil the same indications as my fourth device. The only difference it presents is the replacement of the steel spring by two rubber bands (Fig. 1, AA) which are stretched by the sole fact of the piston being raised (Fig. 2, DD). The bands, returning on themselves, lower the piston into the pump body. This arrangement is ingenious; the bands may have the disadvantage of breaking due to too much tension, as I have sometimes observed in my experiments on animals.



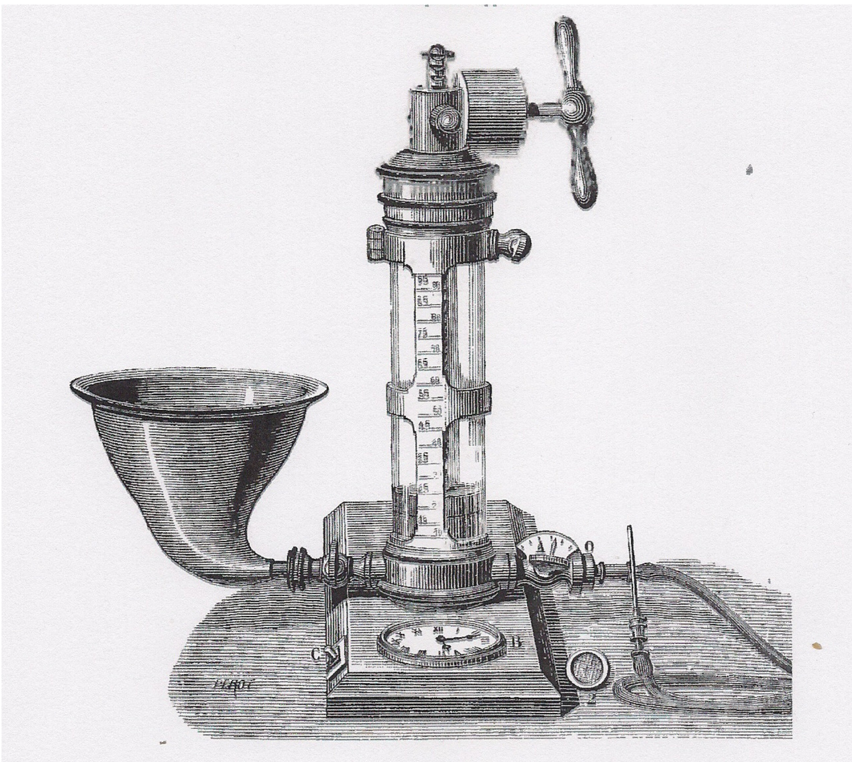
Gendron's apparatus (Plate 5)

I recently made important changes to my fourth device, which makes the mechanism cleaner, more precise, and easier.

1. The pump body, made mobile, can be straightened at will and placed in the vertical position, a more suitable arrangement to block the entry of air.
2. Above the outlet tap, on which a needle is implanted, I had a graduated dial A of semi-lunar shape placed. Each point of the graduation of the dial corresponds to a certain degree of the exit opening; and, depending on whether the end of the needle is placed in turn on these different points, a flow is produced by the cannula which varies as to its force of projection.

Thus, the needle is placed on the first point, immediately the piston descends itself into the pump body, driving the blood in front of it, which then flows drop by drop. If we come to place it on the second division, the flow becomes a little faster. While in the first case the pump body takes four minutes to empty, it only takes two in the second. With the third division, the movement is further accelerated: the pump body empties in one minute; with the fourth, in less than thirty seconds.

Thanks to this arrangement, the surgeon, not having to take care of operating the crank of the apparatus, since it operates on its own, only lowers the piston as in the Eguisier irrigator, can with one hand keep the cannula motionless in the pricked vein, while with the other he places the regulating needle on such or such point of the graduated dial, which gives it the flow force which seems most suitable to him. Thus, the transfusion is done on its own without difficulty, with perfect uniformity in the flow of blood, which does not offer the slightest jerk. Should the patient come to present some particular phenomena that requires the momentary suspension, one has only to turn on tap A, and everything stops.



Oré's apparatus – Fifth Device

I have practiced blood transfusion several times at Saint-André hospital in Bordeaux in front of a very large audience, who were surprised at the simplicity of the operation performed with this device.

Fig. 2 [Note: This is included within the line drawing of Oré's fifth device – see above – to the right of the base plate] represents the movable metal sieve that is located at O/ at the outlet opening of the device. Part O, to which the rubber tube terminated by the cannula is fixed, unscrews with extreme ease. It follows that if it becomes necessary during the operation to unscrew this part because either a coagulum or some foreign body stopped by the sieve prevents the flow of blood, the manoeuvre is done with the greatest ease, the screen is replaced, and the operation continues. In a transfusion made by Professor Gintrac, as I said earlier, this complication occurred: those who were present were able to appreciate the usefulness of the sieve and the ease with which it is changed.

Finally, to give more precision to this research, I had a dial B placed in front of the device. The small hand goes, in one minute, from one division to the next, while the large hand goes around completely in sixty seconds.

To set this dial in motion, all you have to do is press button C back and forth: immediately the needle starts; by pressing the same button from back to front, the needle stops.

It can therefore be understood that as soon as the crank starts to move, it is possible, by pressing button C only, to set the needles of the large dial in motion, and to stop them when the piston has reached the bottom of the pump body. We will thus have, to within one second, the duration of the operation.

The vessel intended to receive the blood of the bleeding being screwed [sic; i.e. in place?], is used for the mediate transfusion. To perform immediate transfusion, I replace it with a tube similar to the outlet tube.

I can therefore, with my device, perform both types of transfusion. I repeat, and all those who have witnessed it will say it with me, nothing is simpler, easier, and more accurate than the transfusion of blood made with this device.

A word more on the operating method: In all my transfusions on humans, as in my intravenous injections, I have always punctured the vein straight away without stripping it. Denudation is a bad manoeuvre that should only be resorted to when it is absolutely demonstrated that there is no other way.

My method was only used by professors Soupart, Deneffe, Wan Wetter; by my friends Drs Lande, Poinsot, who were able to appreciate all the advantages.

It is with this instrument that I recently practiced blood transfusion in town and at the clinic of Professor Gintrac.

As the two patients are still in treatment, I will content myself with summarizing the two facts in a few lines.

First observation: Profound anaemia dating back several years without appreciable damage to any organ. The patient, however, presents cerebral laziness, difficulty in speaking, sometimes even a little inconsistency in ideas, which may give rise to fear of a cerebral lesion. Extreme paleness, livid skin; absolute discoloration of the mucous membranes; almost complete obliteration of the pulse; noticeable weakening of heart palpitations.

A first transfusion of 180 grams of blood immediately produces a noticeable improvement. The face is coloured, the pulse is raised, and during the following days the sphygmographic tracings make it possible to note the happy [improved] modifications that have occurred in the circulation.

Two days after this transfusion, the patient, who had not left his bed for a long time, got up and walked around the room alone twice.

Eight days later, another transfusion of 275 grams of blood [was given], followed by a third of 60 grams. The patient's general condition has improved, but he still requires recourse to a fourth transfusion, which will be made with lamb's blood.

Second observation. - Profound anaemia caused by rebellious diarrhoea, contracted in Cochinchina, [part of Vietnam] and which dates back more than eight months. Subjected to various medications, the patient's condition was always worsening. A consultation with my friends Doctors Gintrac, Levieux, Lande, Poinsot, having decided to resort to transfusion, I practiced it in the presence of these honourable colleagues.

145 grams of blood were introduced. The resulting improvement was immediate. The diarrhoea has diminished; the stools have become less frequent and abundant, and are no longer accompanied by the intolerable pains that the patient was experiencing before the operation. Nevertheless, a new transfusion is still necessary; it will be done soon.