

**RECHERCHES EXPÉRIMENTALES SUR LA TRANSFUSION DU SANG.  
THÈSE POUR LE DOCTORAT ÈS-SCIENCES NATURELLES.**

**BY: DR. ORÉ**

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**A TRANSLATION BY PHIL LEAROYD**

A copy of Dr Oré's thesis for the Doctorate in Natural Sciences titled 'Experimental research on Blood Transfusion', defended before the Faculty of Sciences, Bordeaux on the 28<sup>th</sup> December 1865, can be read or downloaded from either of the following sites:

<https://www.babordnum.fr/items/show/329>

<https://www.babordnum.fr/files/original/7f1132b0d9b46b3368d65e60d76c3771.pdf>

**NOTES:**

1. The links identified above open to Dr. Oré's two submitted theses – the second is titled: 'Experiences on the production of lower algae' – which occur together in the same PDF document. Some of the illustrations relating to his first thesis on blood transfusion have been placed at the end of his second thesis.
2. Within the thesis, Oré refers to an earlier work of his on the history of transfusion, published in 1863 in *Recueil des Mémoires de la Société des Sciences Physiques et Naturelles de Bordeaux*, a copy of which does not appear to be available via the internet.

The author states that his thesis is separated into three parts; the first describes (and illustrates) the different devices used to perform a blood transfusion, the second part summarises his experiments on whole blood and 'blood constituents' and the third is an appraisal of the role / action of fibrin, in relation to both coagulation and the production / use of defibrinated blood.

The first section includes descriptions of the devices used by Lower and Dieffenbach for immediate transfusion, together with Dieffenbach's hydrocele syringe, Mathieus' modified syringe and Moncocq's hematophore used for mediate transfusion. Oré also describes (later within his thesis) the development of his own device for mediate transfusion, through four (illustrated) modifications based on him taking into account his own experimental results. The second part of the thesis describes his own (and other researchers) results into the observed effects of 'blood as it comes out of the veins', together with results using separated 'globules' (red cells) and serum, which identifies that the resuscitating effects of blood seen in exanguinated animals is due to the globules and not the serum.

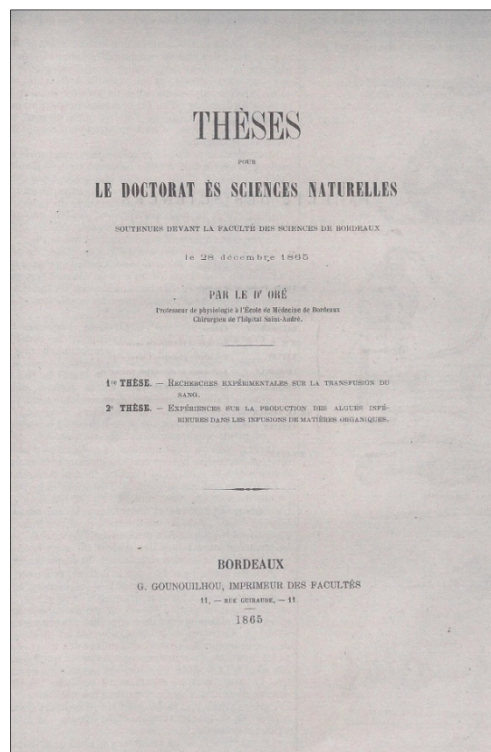
Oré then describes how these results led him to investigating ways of preventing or delaying coagulation when using mediate transfusion. Essentially this work identifies that avoiding contact with air and reducing the temperature of the blood to be transfused slows down coagulation, though he describes that these actions together result in 'most of the blood still being fluid'. Although he identifies that contact with surfaces other than the inside of blood vessels activates coagulation, he does not investigate the possible effects of this. This is exemplified by the fact that although the avoidance of contact with air and reducing the temperature of the blood are the criteria that he uses to describe the development of his own transfusion device (mentioned above), he ignores the detrimental effects of the blood being in contact with metal valves, etc. within mediate transfusion devices.

The third part of the thesis investigates the role of fibrin in transfusion, in which he identifies the need to filter the defibrinated blood before transfusion and the observed

potential 'reviving properties' of defibrinated blood, much of which is quoted from the work of other people. Together though, this results in his comment that the use of defibrinated blood for transfusion in humans 'is useless'.

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

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



Title-page: Recherches expérimentales sur la transfusion du sang.  
Thèse pour le doctorat ès-sciences naturelles. Bordeaux (1865)  
(Image credit: [www.babordnum.fr](http://www.babordnum.fr))

## EXPERIMENTAL RESEARCH ON BLOOD TRANSFUSION

In 1863 I published in the *Recueil des Mémoires de la Société des Sciences Physiques et Naturelles de Bordeaux*, a very detailed history of the transfusion of blood, an operation which consists of passing through the vascular apparatus of an animal the blood taken from another animal. I shall therefore not return to this point, which has been developed with all the scope that such a subject entails. My aim in this new study is to approach the question from the experimental point of view, and to show what vivid light physiology can throw on the solution of the problems which most interest the physician and surgeon.

I will divide my work into three parts:

In the *first* part, I will describe the devices used at various times to perform the transfusion.

The *second* part will be devoted to the presentation of my experiments in transfusion, made either with the blood as it comes out of the vessels, or with each of the elements of which it is composed.

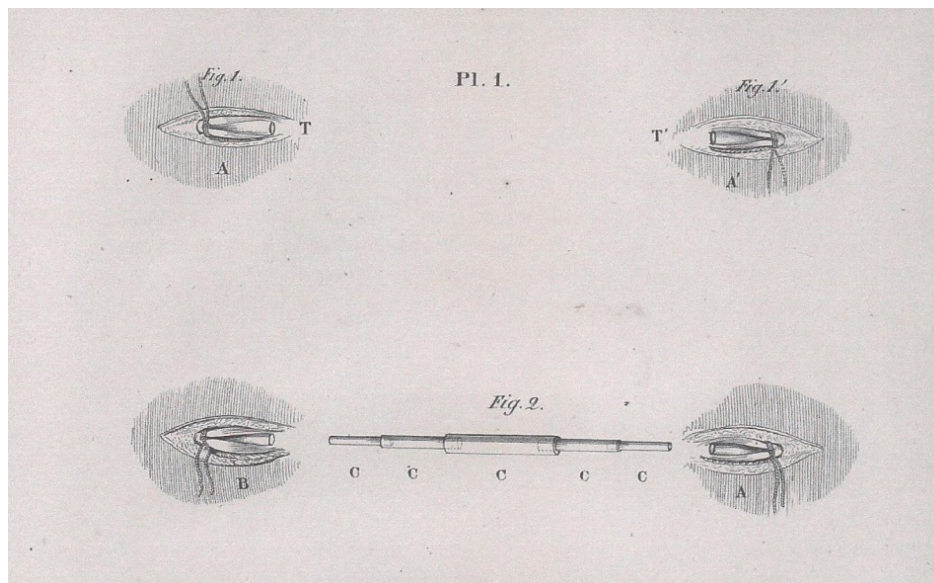
In the *third*, I will appraise the role of fibrin.

### Devices used to perform blood transfusion.

1°: *Richard Lower's apparatus*. Richard Lower was the first to describe an apparatus and a method for carrying out a transfusion. This is what they consist of: the carotid artery of an animal being exposed, he places two threads around it, one inch apart from each other. After this, he opens the vessel and inserts a *small feather pipe*, which he ties tightly, taking care to stop its free end. To make it easier to understand the manoeuvre, I will call this first tube, the *carotid pipe*. Then, discovering the jugular vein of another dog, he also placed two ligatures between which he made an incision in the wall. *Two pipes* are placed there: one, directed towards the side of the head, which I will call the *cephalic pipe*; the other, on the side of the heart, or *cardiac pipe*. The first is intended to let the blood flow, in order to exhaust the animal; the second, to receive the transfused blood. Things being thus arranged, the two dogs are brought closely together and the interval which separates the carotid pipe and the cardiac pipe is filled by a series of pipes articulated with each other: *the blood thus passed through an apparatus of feather pipes running from the artery to the vein, and united together at their ends*.

Figure 2, PL. 1, shows Richard Lower's apparatus.

A is the cardiac tube, B is the cephalic tube, CCCC is the intermediate tubes.



This device, described in a letter addressed to Robert Boyle by the English surgeon, was mentioned in 1667, by the *Journal des Savants*. Denys and Emmeretz employed it in France. Although very ingenious, it has a serious drawback: that of allowing the air contained in the different tubes to penetrate into the vessels. This quantity of air was certainly very small; but if we consider that it occurred in animals weakened by previous haemorrhage, we will understand that it could cause accidents. Be that as it may, Richard Lower's apparatus rendered important services to the transfusers of the 17th century.

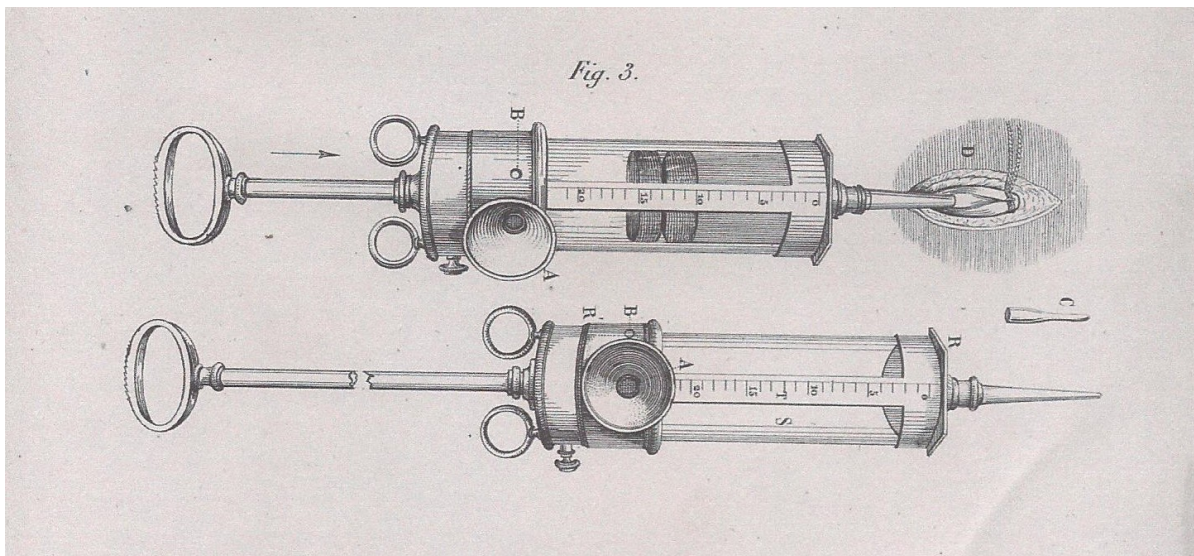
With Blundell, we see the appearance in 1818 of a new and more complicated apparatus than the previous one. As this apparatus has never, or almost never, been used, it is useless to describe it.

Dieffenbach performed *immediate* transfusion and *mediate* transfusion.

In the first case, he used a tube inserted into the artery of a dog at one end and at the other end into the jugular vein of the animal he wanted to transfuse. This is Richard Lower's process. It differs, however, in that the latter joined together a number of feather pipes, while Dieffenbach used only *one tube*.

For the *mediate* transfusion, he resorted to the *injection syringe*. The blood being collected in a vase, Dieffenbach filled the instrument, and pushed the liquid into the vein.

The *mediate* method of transfusion having been preferred by most surgeons, the hydrocele syringe was usually used to perform it; but no matter how well calibrated the pump casing may be, it is not always safe from the penetration of a certain amount of air. Therefore, in order to avoid this inconvenience, Mr. Mathieu, the skilful manufacturer of surgical instruments, has, according to the indications of my excellent friend Professor Pajot, modified the device in the following manner (PL. 1, Fig. 3).



The main part of the instrument consists of a syringe S (Pl. 1, Fig. 3), whose pump body, made of very strong crystal walls, terminated by metal ends (RR'), connected together by two lateral rods T provided with a graduation which gives the measurement of the contained liquid. At the lower part of the instrument is a funnel A, mounted on a friction collar that communicates with the inside of the pump; a hole B, arranged in the same manner, intended to leave a free outlet for the air when the blood of the man who supplies it enters the syringe through the funnel. As soon as the instrument is loaded, a small rotational movement is made to the collar, and the two communications A, B are intercepted; the piston is then pushed while holding the instrument in the vertical position. In this way, it is purged of air at the same time. The cannula is immediately placed in the small ivory tube C, which has been previously placed in the vein D, and which serves as a conductor for the injected liquid.

I do not dispute the usefulness of the changes that Mr. Mathieu has introduced into the mechanism of this instrument. Suffice it to say that I have never made use of it, and that in none of the many observations I have collected have I found any mention of its use.

*Moncocq's hematophore.* – The Moncocq hematophore is an ingenious and convenient instrument for performing the transfusion. The aim of the originator is summed up in this proposition: *to connect, by an uninterrupted current, a plethoric subject destined to supply blood, and an anaemic subject destined to receive it.*

The middle part of this intermediate circulating instrument is a small graduated glass cylinder, playing the role of an artificial ventricle in which a solid piston forms the systole and diastole, by its alternating movements of elevation and descent.

Two small, highly sensitive valves CC' (Pl. 2), placed in opposite directions at the lower part of the artificial ventricle, are used to direct the blood stream. These valves are joined to a capillary tube, made of rubber, 15 to 20 centimetres long. Each capillary tube is terminated by a curved silver needle, canaliculated, and carrying on its convex part, 15 millimetres from its tip, an opening which terminates the canal with which it is pierced.

The blood in the vessels being perfectly liquid, if its instantaneous contact with an unorganized tube did not coagulate it, it would have to pass through the apparatus according to the physical laws of ordinary liquids.

Now, this is how, in Moncocq's thinking, the hematophore should function: given two animals immobilized for the transfusion, the vein of the animal which is to receive the blood is punctured with the needle DO, so that the opening O of the canal which it carries to its convex face, after having crossed the vein at two points, comes out.

With the second needle D'O', the vein of the animal which is to give the blood is similarly punctured, with this difference that the aperture O' of the needle D' is in the very centre of the vein, and plunges into the bloodstream.

The two needles being thus arranged, if the diastole is made in the cylinder by raising the piston B, the first effect of the vacuum which is produced is to open from the outside to the inside the valve C', which is pressed first by some bubbles of air contained in the tube, and immediately by the blood which flows from O'.

If the systole is then performed by lowering the piston, the blood and air are expelled from the ventricle in CDO, and everything comes out 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 into the centre of the vein which is to receive the blood, the current is established, and it only remains to operate the ventricle, each systole of which expels a wave of blood proportional to the movement that is imparted to the piston, a wave of blood which can be evaluated, by the graduation in grams of the crystal cylinder.

I have used Moncocq's apparatus several times, and I affirm that no other is more useful and easier to handle.

The time has come to describe all the instruments that I myself have imagined over the past four years; but, in order to give a better understanding of the indications that I wanted to fill in by modifying their form several times, I prefer to refer the description of them to the account of my own experiences.

## SECOND PART

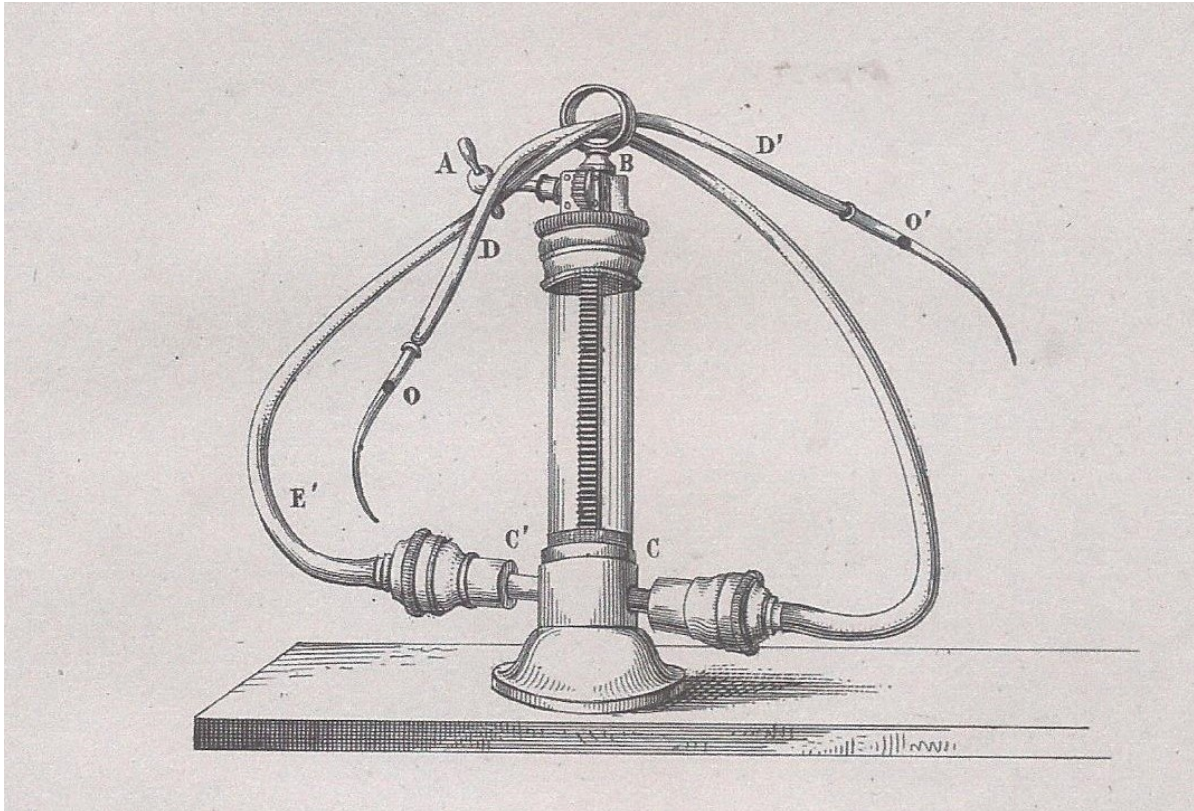
Having described the various devices invented for the purpose of mediate or immediate transfusion, I am now proceeding to study them from the experimental point of view. Experimentation alone can in fact bring this operation into practice, for it alone can solve all the problems connected with it.

The first question that arises is this:

*Is it possible to bring back to life an animal that has been rendered bloodless by a severe haemorrhage, by introducing blood taken from another animal into its vessels?*

The experiences of Denys and Emmeretz, Richard Lower, Blundell, Dieffenbach, Bischoff, Magendie, Nicolas, Longet, Moncocq, etc., mentioned in my first Memoir, can leave no doubt on this point.

My many experiments, undertaken over the past four years, also allow me to answer in the affirmative. I won't report them all. I will content myself to citing only one, which offers all the guarantees of authenticity, because of the exceptional conditions under which it was carried out.



PL 2: Moncocq's apparatus for blood transfusion

The cylinder of the middle part is made of crystal; it is graduated in grams and has a capacity of 30 grams.

B: Piston rod intended to alternate between diastole and systole outside the cylinder

C': Valve opening from the outside and inside of the cylinder at the time of diastole

E/D': Tube used for blood supply

O': Opening on the convex part of the needle for the entry of blood into its channel

C: Valve opening from the outside and inside the cylinder at the time of systole

O: Opening on the convex part of the needle for the blood to escape from its channel

Note: Needles D'O' and DO have a much more pronounced curvature than in this drawing

On a recent trip to Paris, I was speaking with Mr. Gosselin, professor in the Faculty of Medicine, about all the difficulties involved in the treatment of cholera, and I urged him to try to cure it by transfusion of blood. I offered to assist him at some experiments which I was then carrying out at the Practical School, in the laboratory of my excellent teacher and friend, Professor Longet. He accepted my offer, and I had the good fortune to make him witness the following fact, which was also witnessed by Professor Robin, Mr. Lucien Corvisart, and Mr. Labbé, hospital surgeon, who lent me, on this occasion, his enlightened and friendly assistance.

Two large dogs having been tied side by side, I exposed the left crural vein of one and the right crural vein of the other. I removed from the crural artery of the first, two large test-tubes of blood, the quantity of which may be estimated at about two or three pounds. Soon

the chest movements stopped. The ear, applied to the precordial region, distinguished a sort of dull murmur which had replaced the beating of the heart; the muscles of the limbs and neck were in a state of complete relaxation. The animal appeared almost dead. Then, plunging the cannula of Moncocq's apparatus into the vein of the dog which had suffered no haemorrhage; I passed 90 grams of its blood into the vein of the one whom I had rendered bloodless. As soon as the liquid began to penetrate, the movements of the chest reappeared. Those of the heart became more perceptible. Life seemed to be reborn as if by magic; after a minute and a half, the dog opened its eyes, the muscles in his neck and legs contracted. At the end of the third minute, the dog was saved. I quickly untied it, after having tied the vessels; immediately he jumped from the board and began to walk about the apartment.

It will be easy to understand, from the account of this experience, the emotion of all those present, and their astonishment in the presence of an operation which had brought about an instantaneous resurrection in an animal so near death.

A similar experiment was carried out at the Faculty of Medicine in Paris, in June 1863, with the same instrument and the same success, by Professor Longet.

When one has witnessed such facts, it is impossible not to remain convinced of the immense services that blood transfusion can provide in the treatment of certain haemorrhages, against which all the means available to therapy so often fail.

From this experience, and from many others like it, I am entitled to conclude that *transfusion can bring back to life an animal made bloodless by a severe haemorrhage*. But blood is made up of three elements, serum, globules, and fibrin. It became interesting to research into the part played by the first two in these phenomena of true resurrection.

1° *Experiments carried out with serum*. – Dieffenbach had already tried in vain to save bloodless animals by transfusing them with a fairly large quantity of serum. Magendie had come to the same conclusions. He injected 300 grams of human blood serum into the veins of an adult dog: it died within twenty-four hours. He repeated the experiment with the serum of blood taken from a dog of the same breed as the one into whose veins he was injecting: death nevertheless occurred. Finally, it is known that partial transfusions of serum had been carried out without more success in humans to combat cholera.

I have done ten experiments with the serum in dogs, rabbits and chickens. They all led me to this result:

*The serum of the blood introduced into the veins of a bloodless animal has never succeeded in reviving it.*

I will also remark that, like Magendie, I have not been able to keep an animal alive for twenty-four hours. Most often the dogs died after five or six hours. This difference may be due to the fact that the amount of blood lost by my animals was greater.

Therefore, *serum injected alone cannot revive an animal exhausted by considerable blood loss*.

Is it the same with globules? The last conclusion led us to believe that, since transfusion can advantageously combat the fatal effects of haemorrhage, it is to the globules that the blood owes its revivifying properties. The following are the results of six experiments carried out with the *globules* alone, on two dogs, two rabbits, a rooster and a hen.

*Experiments*. – Having removed from two dogs a quantity of venous blood large enough to weaken them considerably, I gently dropped a trickle of water over the clot. I obtained by *washing*, a strongly reddened liquid, where the microscope enabled me to ascertain the presence of blood globules in a state of perfect integrity, but distended by the water which had passed through their walls. I injected this fluid into the crural vein. The good effects of the operation were long awaited. In the two dogs, life came back only very slowly, because for the first six days they remained so weak that I feared, for a moment, that they would die. Gradually, their strength returned and the two dogs recovered. I saw the same result on a rabbit. The other rabbit, the rooster and the hen died, the first after twenty-two hours, the others after eight and ten hours.

Therefore, in *three* out of *six* experiments, I obtained advantageous effects by transfusion of the globules alone, held in suspension in water. Nevertheless, I have no hesitation in saying that if the globules are the really active part of the blood, it would sometimes be dangerous to rely too much on them.

I am therefore led to study the action of the blood itself.

### **Transfusion experiments performed with blood as it comes out of the vessels.**

Blundell carried out *mediate* transfusion experiments with *non defibrinated* blood. He used an injection syringe. The first question he asked himself was whether *the passage of blood through the syringe did not render it unfit to reviving functions.*

*First experiment.* – The femoral vein having been exposed in a dog, the surgeon introduced a tube into the artery, by means of which he drew eight ounces of blood from the animal in two minutes.

The most alarming symptoms soon appeared: difficulty in breathing, convulsions, profound fainting marked by the cessation of circulation, by loss of sensation, by a complete relaxation of the abdominal muscles.

After a few seconds, six ounces of blood were taken from the femoral artery of another dog and injected into the vein. The animal revived, breathing became regular, and sensibility was restored. This resurrection was so complete that the animal seemed to awaken rather than emerge from a state of apparent death.

*Second experiment.* - The femoral vein of a dog was exposed, and a tube was introduced into it, as well as into the artery: as the blood escaping from the latter vessel fell into a vase, it was immediately introduced into the vein.

This operation was continued for *twenty-four minutes*, and the dog did not appear to be inconvenienced. Now, in order for this experiment to have been prolonged for twenty-four minutes, it is necessary, says Blundell, that *the same blood should have passed through the instruments several times.*

From these two experiments, he concluded *that blood could be transmitted by the syringe, and this several times, without becoming unfit for vital functions.* I accept the first part of the conclusion, namely, *that the passage of blood through an injection syringe does not prevent it from retaining its regenerative properties.* No experimenter will dispute this; but what I absolutely deny is that the blood was able, for twenty-four minutes, and on several occasions, to pass through the syringe without losing the qualities which are indispensable for the transfusion to be *carried out.* I shall shortly point out the facts on which my denial is based.

After Blundell comes Dieffenbach, who practiced transfusion in two ways:

1° *Immediate* transfusion by means of an intermediate tube from the artery of one animal to the vein of the other;

2° *Mediate* transfusion by means of a syringe.

Dieffenbach performed *immediate* transfusion eleven times. I will cite only one of these experiments, all the others being similar in the process followed and the results obtained.

He opened the carotid artery to a small dog and let the blood flow until the animal no longer showed any signs of life. This state of apparent death was preceded by violent convulsions; during nervous accidents, the pupil dilated and contracted alternately, until it remained completely and largely motionless.

At this time, the jugular vein was opened. A tube being then placed in the carotid artery of the first and in the jugular of the other, the blood passed into the vein of the latter. The dog seemed to breathe better at first, but he did not survive.

Performed on six dogs, two cats, an old sheep, a calf and a bull, this experiment was followed by the death of three dogs, a cat and a bull. All these animals perished more or

less quickly. The other three dogs, a cat, the sheep and the calf, gradually recovered, and regained their health after a variable time, from a few hours to three days.

*Immediate* transfusion, therefore, can sometimes save life, says Dieffenbach; but, even in fortunate cases, it is not without danger.

On the contrary, by practicing *mediate* transfusion, two-thirds of the animals were brought back to life.

In spite of the respect I profess for the great German surgeon, I will allow myself a few observations. And in the first place, is it permissible to proscribe an operative procedure which has yielded six successes out of eleven cases? Are not operations performed every day in hospitals which do not enable the surgeon to record such fine results? Secondly, is the immediate transfusion to blame for the five setbacks, or the manner in which it was performed? If one thinks about it, it will soon be realised that the intermediate tube used by Dieffenbach is essentially defective. To establish a link between the animals, this tube had to be of a certain length, and consequently contain a *fairly large quantity of air*. Now, the blood could not pass from one animal to another, without pushing the air enclosed in the tube before it. My experiments have taught me, it is true, that a small proportion of this gas can circulate in the vascular system without immediately endangering the life of an animal; but this is only possible when the animal *has not previously been exhausted by severe haemorrhage*; this is no longer the case when the latter circumstance occurs. Blood loss decreases the movement of the heart; they weaken them and slow them down a lot. If air, even in small quantities, arrives in the right cavities and distends them, death will not always occur, but it will often manifest itself, especially if the animals are small. Therefore, far from accepting Dieffenbach's reproaches against *immediate* transfusion, I shall soon demonstrate, by the aid of facts, that this procedure is preferable to all others.

Like Blundell, Dieffenbach wanted to ascertain how long the blood drawn from the vessels retained its property of revivifying animals, and he came to think that after three hours it lost its action.

So, for three hours, the blood has this regenerative power. I oppose this fact with the same denial as that of Blundell. I could multiply the quotations and relate the numerous experiments that have been carried out with blood containing its three constituent elements: *serum, fibrin, globules*; I will not however; I prefer to present the facts that are personal to me.

When I began my studies on the transfusion of blood a few years ago, I did not conceal from myself all the difficulties of such a subject. This operation, which enjoyed such exceptional favour in the second half of the 17th century, had scarcely any supporters, in our own time, among the most justly esteemed men of science. The history that I published in 1863 proves this abundantly. I had, therefore, to contend with fixed opinions and repugnances which seemed invincible. I understood that experience alone could change the course of thought, and restore to the transfusion of blood the rightful place it deserves. So I experimented.

Encouraged by the example of Blundell and Dieffenbach, I thought of practicing transfusion by means of the syringe which is used, either for preparations of the blood system, or in some surgical operations, such as hydrocele.

The animals I chose were dogs, rabbits, cats, chickens, ducks, etc., etc. Having in mind the experiment in which Blundell had been able to pass *the same blood* through the syringe, for *twenty-four minutes*; knowing also that the Berlin surgeon had established that this liquid *drawn from the vessels retained* the property of revivifying the animal *for three hours*, I thought that my experiments would be carried out with extreme simplicity. Unfortunately, from the very beginning, I found myself in the presence of a difficulty that I thought for a moment insurmountable: I had reckoned without the rapid coagulation of the blood. But the narrative of the facts will speak louder than all reasoning.

*First experiment.* – After having exposed the crural vein on two dogs, I placed two ligatures around this vessel in the animal to which I wanted to perform the transfusion. One of these ligatures was to interrupt the return circulation; the other, obliterate the vessel after

the operation. Things being thus arranged, I made a very large opening in the vein of the dog which was to supply the blood, so that the flow might be easy and rapid; I collected it in a vase placed in the middle of a bain-marie heated to 38 or 40°. The vessel, therefore, could not cause the blood to undergo any cooling. In spite of these precautions, I noticed that a few seconds after it was discharged, *part of the blood was already coagulated*. Nevertheless, I loaded the syringe, inserted the tapered end of the cannula into the vein, and pushed the injection. The piston initially worked quite well in the pump housing. But it was soon stopped, and in spite of the too-and-fro movements I gave it, the blood no longer penetrated, and the dog succumbed. Wishing to ascertain exactly the cause of this fatal outcome, it was easy for me to ascertain that the greater part of the blood contained in the syringe was *solidified*, and that the obstacle to the circulation of this fluid was constituted by clots which obliterated the cannula.

The experiment had lasted only about two minutes. Fearing, however, that this negative result depended on the operator, I repeated it on another dog, taking care to observe the same conditions and to collect the blood in a previously heated vase. Everything went smoothly and quickly. Nevertheless, the animal succumbed. Death was due to the same cause: *the presence of clots that blocked the cannula*.

On rabbits, cats, and chickens, I was no happier in the twenty-two experiments to which they were subjected. This first result was, it must be admitted, not very encouraging; but it gives reasons for the absolute denial which I have opposed: 1° to the opinion of Blundell, on the property of the blood to pass through the injection syringe for twenty-four minutes, while always remaining *fit* to be transfused; 2° to that of Dieffenbach, who acknowledges the same faculty for three hours.

It became necessary to modify the experimental conditions by looking for ways that could delay or prevent coagulation.

To avoid unnecessary repetitions, I will say, once and for all, that I have always transfused the blood from vein to vein, sometimes choosing the crural, sometimes the external jugular, and the animals were always arranged as in the two preceding experiments.

The first modification I made was to receive the blood *in a vessel which had not been previously heated, and which was in equilibrium with the temperature of the surrounding environment*.

*The first experiment was made in November 1862, when the outside temperature was 13° above zero.*

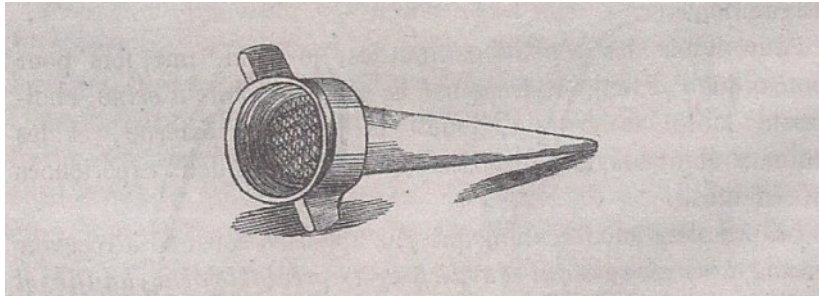
I collected 100 grams of blood, taken from a large hunting dog, in a measuring cup that could hold 150 grams of water. I first observed what was going to happen. For the first two minutes, the blood seemed quite liquid. Towards the end of the second minute, the phenomena of coagulation appeared. In the middle of the liquid mass, I noticed the existence of small coagulums. From that moment on, the latter became more numerous.

Rabbit and chicken blood offered much the same characteristics.

A few days later, the outside temperature having fallen to 7°, I repeated the same observations, and was able to verify this fact: *that the lower the outside temperature, the more delayed is the coagulation of the blood*. The problem became simpler, and the chances of success for transfusion, with non-defibrinated blood, became more favourable.

I then thought of taking advantage of the new circumstances which observation had revealed to me, and of repeating the unfortunate experiences previously related. Convinced, however, that small coagulums might have escaped my investigations, when the blood appeared quite liquid to me, and that their entry into the vessels would cause serious accidents, I subjected the injection syringe to the following modification:

I placed in the flared part of the cannula a flattened circular steel frame, on which was stretched a wire canvas, the network of which, with a very tight mesh, was to retain the small clots and allow only the part of the blood that remained liquid to pass through. With the help of this modification, I was able to experiment on four dogs and three rabbits.



*Experiments.* – Three dogs having been reduced to a state close to death, following a puncture of the carotid artery, I transfused them with 100 grams of blood, the temperature of which had fallen to 6°. All three dogs were brought back to life. The same result was obtained in one rabbit. One dog and two rabbits died. Rather large clots, which had become entangled in the meshes of the wire mesh, had, in the latter animals, prevented the blood from passing through the cannula.

It was a pretty good result. The cold delaying coagulation gave the operator one more chance of success.

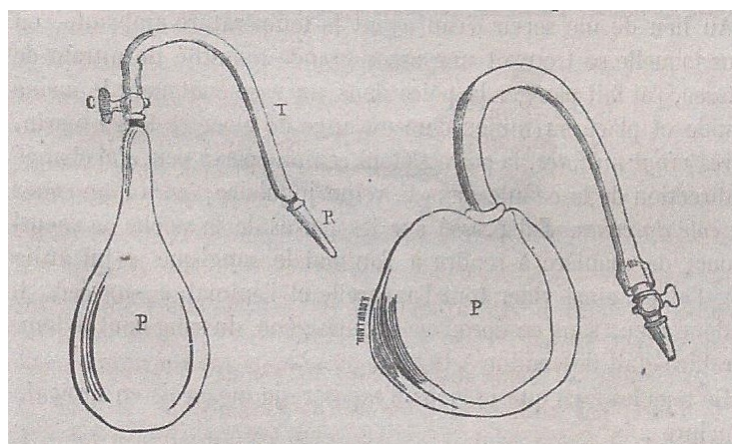
I thought it necessary to persevere in this path, and to look for other circumstances capable, with the refrigeration of the blood, of delaying the formation of the clot.

And at first I thought of preventing the contact of blood and the outside air.

### **Experiments demonstrating the influence of air contact on blood coagulation.**

These experiments already date back two years. I repeated them recently, in my laboratory at the School of Medicine, in the presence of my friend Mr. Merget, professor at the Faculty of Sciences of Lyon.

*First experiment.* – In order to avoid the contact of air with the blood, I have used, to collect the latter, a rubber bulb P, fitted with a copper tap C, which can be opened and closed at will. From the tap comes a tube T of the same substance, 20 centimetres long, and terminated by a cannula R whose opening is 5 to 6 millimetres in diameter. After having evacuated the bulb with suction, with the tap C closed, I introduced the tapered cannula R into the jugular vein of a medium-sized dog. I then turned on the tap. The blood, attracted by the vacuum, began to flow through the rubber tube and fill the bulb. *After ten minutes*, I noticed, and Mr. Merget was able to observe with me, an obvious fluctuation, by pressing on the sides of the container. Wanting to assess the state of the blood, I opened the valve, and I was able to see that *it was still liquid*. It did contain a few isolated clots; but it could have been transfused without causing any accident, especially if care had been taken to use the modified syringe as I have said.



This experiment was of real interest, when we consider that the dog's blood, when brought into contact with the air, coagulates almost immediately.

*Second experiment.* – The apparatus and the dog being arranged as before, I immersed the rubber bulb into a vase filled with water, in which I had dissolved a considerable quantity of nitrate of potash, in order to lower the temperature. The thermometer marked 4 to 5° in this saline dissolution. After a quarter of an hour, most of the blood was still liquid.

*Third experiment.* – Encouraged by the results of these two experiments, I attempted a third, which will leave no doubt as to the double influence of cold and deprivation of air in the phenomenon of blood coagulation.

Instead of using water at room temperature, or in which there was a fairly large quantity of nitrate of potash, I plunged the bulb into a vase containing the same liquid and placed in the middle of a mixture of ice and sea salt. After *twenty minutes*, the bulb having filled little by little, I changed the direction of the cannula in the jugular vein, turning it *towards the side of the heart*. I pressed on the sides of the rubber bag, so as to give back to the animal the blood I had taken from it. I was able to empty the whole device, and the animal survived. He therefore received, without feeling any discomfort, blood whose temperature had dropped to 0°.

From all the facts which I have just stated, I believe I have a right to conclude:

1° Blood cannot remain for twenty-four minutes (Blundell) or for three hours (Dieffenbach) outside the vessels under conditions which permit it to be used for transfusion.

2° The venous blood of dogs, rabbits, cats, chickens, ducks, etc., collected in a vessel whose temperature is equal to, or *nearly equal to, that of the body, begins to coagulate as soon as it has left the vessels*. It is then impossible to transfuse it to animals exhausted by severe haemorrhage. If, however, we persist in carrying out the operation, death will occur, either by the insufficiency of the quantity of blood introduced into the veins, or as a result of the penetration of clots, which cause rapid disturbances in the circulation.

3° The more the blood is *cooled*, after it has left the vessels, the longer it takes to coagulate; moreover, therefore, it is in favourable conditions for transfusion.

4° The contact of the outside air with the blood is one of the main causes of coagulation.

5° It is essential, when mediate transfusion is to be carried out by means of the syringe, to make the same alteration to this instrument which I was the first to point out.

6° Blood whose temperature is reduced to 0° has the property of revivifying animals as well as that which has retained the normal temperature.

7° Finally there is another conclusion which I can already suggest, which is that *immediate* transfusion is to be preferred to *mediate* transfusion.

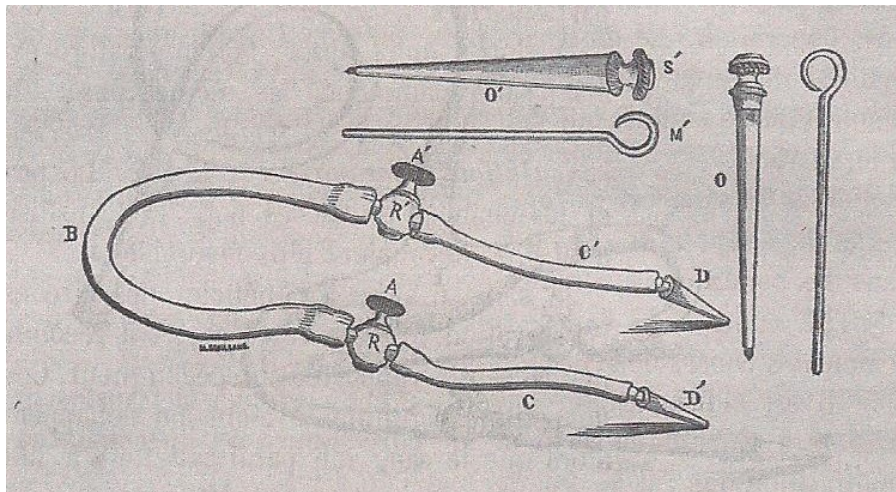
Experiment and observation have taught me that in order for the transfusion of blood to be possible in animals, these two conditions must be met: 1° *to avoid contact with air*, 2° *to cool the liquid*, I found myself obliged to create new devices, for I had at that time only the ordinary injection syringe. The time has come to describe these devices, of which there are four.

My first device consists of a rubber tube B, at both ends of which are two copper taps RR', each with a valve AA', which can be opened and closed at will. Each tap is fitted with a CC' rubber tube which end in very tapered cannulas DD'.

To complete this apparatus, I use: 1° two cannulas OO' crossed by three-quarters SS' (arranged as for the three-quarter explorer). These two cannulas, armed with their three-quarters, are intended, one to puncture the vein into which the blood is to be injected, the other to puncture the vein which is to supply it; 2° two mandrels MM'.

*How to use the instrument.* – I begin by puncturing the two veins between which I wish to establish the blood flow with the cannulas O and O', armed with their three-quarters. Once in place, I remove the three-quarters SS', which I replace with the mandrels MM'. 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 which is to supply the blood, and replace it with the tapered cannula D'. The valves A and A' being open, I make the suction in D. I thus purge the apparatus of the air it contains, and the blood begins to flow. At this moment 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.

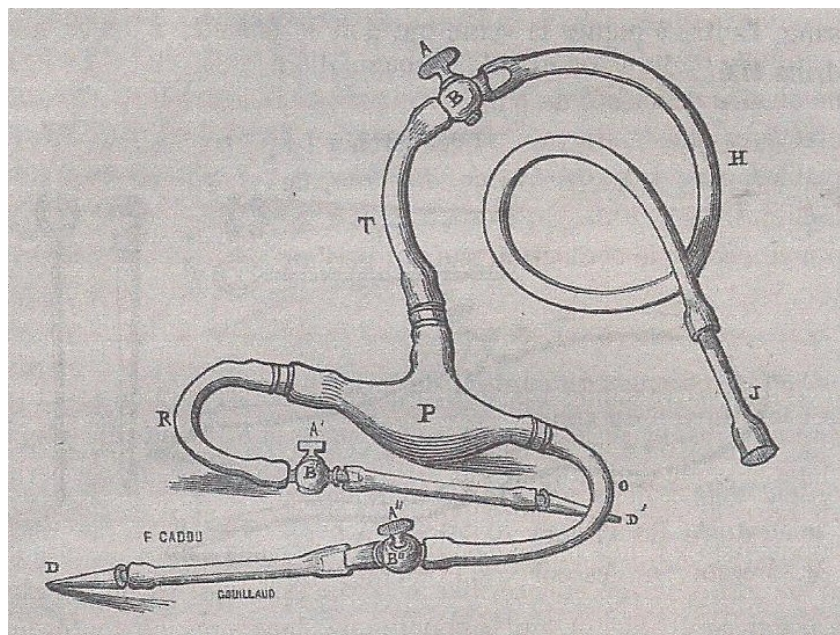


First Device

Although very simple, this device has been of great service to me. It allowed me: 1° to do the immediate transfusion; 2° to prevent contact of the blood with the outside air, and consequently to remove this cause from too rapid coagulation.

It nevertheless had a disadvantage due to the slowness with which the blood flowed through it. So I tried to change it; I tried to achieve this in two ways.

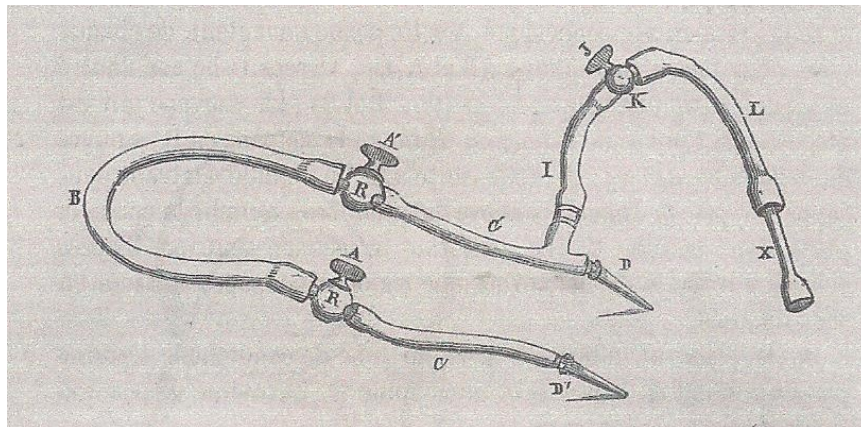
This apparatus consists of a rubber bulb P, from which three tubes T, R, O, originate, terminated by copper taps with globe valves AB, A'B', A''B''. The two taps A'B', A''B'' end in tapered cannulas as in the previous case. The AB tap is joined to a rubber tube H, which has a glass tube J at its other end. The latter, being placed in the mouth, was used to create a vacuum in the apparatus by suction. Moreover, once the cannulas had been arranged as previously said, it was to serve, as a result of repeated aspirations, to bring the blood more rapidly into the bulb P, which, grasped with the hand, could be emptied more rapidly by means of compression.



Second Device

From the first application, I soon realised that this device was less convenient than the previous one. The blood did indeed reach the bulb P more quickly, but once there, the suction continued, the liquid rose in the tube T and flowed poorly through the tube R. I realised that this vacuum tube was placed *too far from the point where the blood was supposed to come out*. I had to change it as follows:

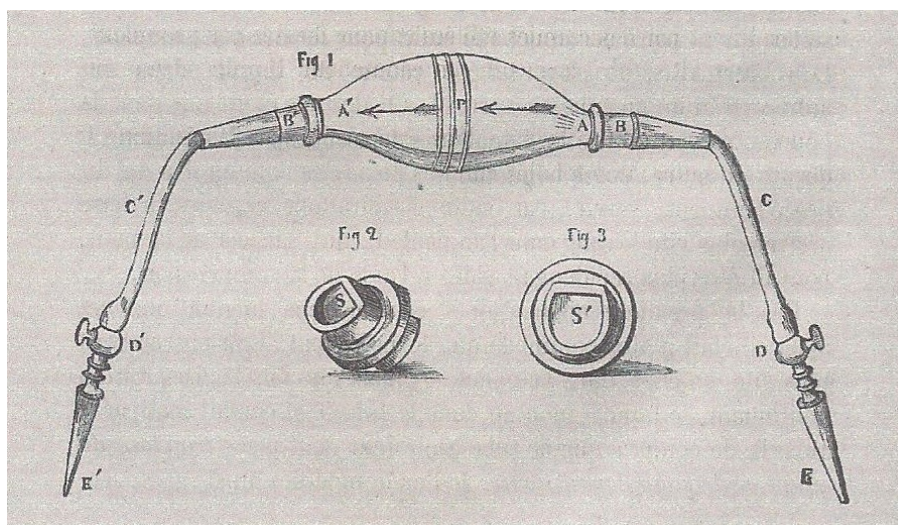
In this third device, which is an exact reproduction of the first, I placed the suction tube *near the cannula* that enters the vein of the animal I wanted to transfuse. It allowed me to create a vacuum, thereby calling in the blood, and to speed up its movement. It offered me serious advantages, but nevertheless it did not yet realize my hopes; I therefore replaced it by the following device, which has worked in almost all my experiments, and which has led me to very fine results.



Third Device

This device consists of a rubber bulb P, ovoid in shape and with walls strong enough to prevent it from collapsing under atmospheric pressure. Two metal pieces AB and A'B' are fitted to this bulb on each side, screwed one on top of the other and separated by a valve SS' (Fig. 2 and 3). The valve which is placed at B opens from the outside to the inside; the valve at B' opens from the inside out, so that the liquid entering the device through the tube C, lifts the first, fills the pocket and passes into the tube C' by lifting the second valve. From this, it is easy to see that the two valves act in opposite directions.

From the metal part B comes a rubber tube terminated by a copper tap D and a cannula E. The same arrangement exists on the opposite side.



Fourth Device

*How to use it.* – After opening the valve D', close D, and press on the bag in such a way as to expel through the tube C' all the air it contains, which is prevented from returning into the device by immediately closing D'. Then the cannula E is placed in the vein of the animal that is to supply the blood. With the tap D open, the blood rushes into the bag, which it fills. The pressure exerted on it causes it to flow into the tube C terminated by the cannula E', which is introduced into the vein of the animal on which the transfusion is being carried out. It is understood that the valve in AB rises to let the blood flow to P, but that the pressure exerted on the rubber bulb is sufficient to close this valve and allow it to prevent the liquid from returning to the tube C.

All these devices were skilfully executed by Mr. Gendron, hernia surgeon of the hospitals.

### THIRD PART.

#### On the role of fibrin in transfusion.

Refrigeration and removal from air contact are not the only circumstances that delay blood clotting. There is one that prevents it completely: I am talking about defibrination. I come to one of the difficult points of this study, one which, as a result of strange interpretations, has given rise to theories which experimentation proves to be false.

And first, does defibrinated blood lose its reviving properties?

Magendie thought so. Here is how he expressed himself in his public lectures of 1837: "Dieffenbach, wishing to rehabilitate blood transfusion, had recommended the extraction of fibrin in order to prevent obstruction of the capillaries. A few months ago, such a procedure would have seemed very rational to me. Today, my experiences have taught me that it is no longer possible. If the fibrin is removed, the animal must inevitably succumb."

*Experiment of 17 February 1837.* – The jugular vein of a dog being exposed and opened, eight ounces of blood were taken out of it, which were collected, beaten to extract the fibrin, which was deposited on the rod in yellowish filaments. The blood was filtered through a fine cloth and then injected back into the vein.

The animal appeared worried: it lay down, refused food and made efforts to vomit. He gradually weakened, his breathing became difficult, and he died in the evening after the second injection.

At the autopsy, carried out twelve hours later, we already observed a most fetid odour of putrefaction, such as is found in all diseases which result from an alteration of the blood, and which the ancients called putrid.

This dog died because the viscosity of its blood was reduced, so that this blood could not circulate in its channels: its serous part extravasated into the lungs through the walls of the capillaries.

On 21 June 1835, continuing the same research, Magendie expressed himself as follows: "Having wished to deprive the blood of the faculty it enjoys to gather en masse, we removed fibrin. The same experiment, repeated many times on different animals, has always given us the same results: the animal always died, and all the more quickly the less normal blood remained. The defibrinated blood can no longer move in the vessels: the serum passes through them by imbibition, it forms congestions and extravasations, chiefly in the lungs, and it quickly leads to asphyxiation and death."

"Thus the same substance which solidifies when it is outside the vessels, but which is liquid in their interior, fibrin, gives the blood the wonderful viscosity necessary to pass through the finest capillaries; and it is interesting to know that this coagulable blood alone is capable of sustaining life: its very viscosity is precisely what makes it circulate."

I agree with Magendie that blood is a viscous liquid; but it is impossible for me to find in its viscosity the principal cause which causes it to circulate. Moreover, are we not entitled to wonder if this viscosity is due to fibrin?

The coagulation of the blood due to fibrin has so preoccupied certain physiologists, Muller, Dieffenbach, Bischoff, that many have advised that transfusion should be performed only with previously defibrinated blood.

My experiments with defibrinated blood have led me to results diametrically opposed to those obtained by the great physiologist. I will remark, before mentioning them, that I have always taken care, after defibrination, to filter the liquid; in fact, filaments of fibrin may remain, which, by entering the vessels, cause serious accidents.

#### Experiments with defibrinated blood

I have done ten experiments with defibrinated blood on dogs and rabbits. I will only mention one.

A large hunting dog having been exhausted by haemorrhage due to a carotid puncture, I gently introduced 120 grams of defibrinated and carefully filtered blood into the right crural vein. The animal came back to life, and the resurrection was almost as swift as when the blood contains all its elements.

The same result was obtained on six other dogs and one rabbit.

Imbued, however, with the conclusions formulated by Magendie on the role of fibrin, Mr. Moncocq does not hesitate to say in his thesis:

"These conclusive experiments of Magendie make us understand clearly that transfusion with defibrinated blood could never succeed in humans. We will see that it has always failed."

Facts alone were capable of overturning this assertion. Let's question them.

#### Chlorosis with cerebrospinal irritation; healing by doctor GIOVANNI POLLI (1857).

A young lady had been afflicted for several years with chlorosis with spinal irritation, for which she had been bled more than three hundred times; it had also been treated with cinchona, ferruginous, tonics, depuratives, narcotics, and resolatives; she had been tortured in every way by revulsives applied to all parts of the body, and all this without benefit, since menstruation had become more and more rare and difficult, especially during the last two years; languid digestion, imperfect nutrition, the skin pale yellow, almost jaundice-like. The patient thus endured a painful existence, leaving her bed from time to time, only to be taken back a few days later by congestive irritations of the head or chest, which obliged the doctors to deprive her again of the little strength she had been able to gather.

For two weeks the patient had been confined to bed with a dry and tiring cough, accompanied by fever in the evening. She had already been bled three times without any reduction in symptoms.

Mr. Giovanni Polli proposed transfusion. Four ounces of *defibrinated blood* by beating were introduced through the right median cephalic vein. Soon after, three ounces were again introduced.

The day after the operation, the cough was gone. Three days later she was able to get up; on the fourth day she left the room to take the steamboat, on which she embarked for a pleasure trip.

The operation had been performed on the 20 October, and at the end of December Mr. G. Polli received a letter from this young lady announcing that she was perfectly cured, and that menstruation, which had been suspended for a long time, had been restored; she did not hesitate to attribute the cure to the transfusion. Mr. G. Polli received news of her again on 15 February 1852, and the recovery had not been denied.

Is it possible to say, after reading this observation, that transfusion with *defibrinated blood can never be successful in humans*? In 1860 Mr. Neudefer gave a blood transfusion at the San Spirito Hospital in Verona to the wounded of the Austrian army. The subjects were all in

extremely desperate conditions; they were reduced to the last degree of stagnation by interminable suppurations, the result of gunshot wounds. The complete loss of appetite and sleep made recovery by ordinary dietary resources an impossibility.

Transfusion was attempted with all the requisite precautions; the blood was injected, defibrinated, and kept at a suitable temperature; its quantity did not exceed three or four ounces; the five subjects who underwent this operation experienced a pleasant sensation of warmth extending from the arm where the injection was being made to the chest. The general condition showed a manifest improvement, the pulse increased in breadth and strength, the patients enjoyed a restful sleep which the narcotic preparations had hitherto been unable to give them, and the appetite was awakened. The improvement in general condition persisted in all for five to eight days; it even lasted ten days, following the second transfusion, in a subject on whom this operation was repeated. But that was the end of the beneficial effect of the transfusion. From that moment on, the patients relapsed into the desperate state which had motivated the therapeutic trial. Of the five operated on, four died after four weeks; the one who had been subjected to transfusion twice lived five weeks. The life of these patients having appeared to be prolonged by a few days at least, Mr. Neudefer intended to continue his experiments, when a sixth patient died shortly after the operation.

This fatal result is attributed by the author to the nature of the blood taken from a subject who was experiencing an imminent attack of gout. He thinks that the blood tainted by the uric acid diathesis must have acted like a poison.

*Reflections.* – From the five facts pointed out by Mr. Neudefer there is one great lesson: the patients had reached a state of extreme weakness, exhausted by abundant suppuration, and reduced to the last degree of marasmus; the appetite was completely zero and the loss of sleep absolute. Under the influence of the transfusion, sleep reappeared with appetite, and the general condition improved markedly. This improvement was only temporary, it is true, but although transient, it was unquestionably the result of the transfusion made with *defibrinated blood*. If the surgeon had performed the operation earlier, at a time when life was less seriously compromised, the fortunate change it brought about in the condition of the patients, instead of being momentary, would have become permanent. When death is about to occur in consequence of a long illness, the transfusion made with blood *containing all its principles* does not prevent it from occurring any more than when this fluid is deprived of its fibrin. But if, in the latter case, an improvement takes place and delays the fatal outcome, is it not fair to affirm that *defibrination* does not cause the nourishing fluid to lose its revivifying properties?

Experimental physiology and clinical observation therefore lend each other mutual support to demonstrate how unfounded Magendie's conclusion on the ineffectiveness of defibrinated blood is. The facts which we are about to examine will remove any uncertainty in this regard.

*Can the blood of one animal be safely transfused into an animal of a different species?*

In April 1865, Denys wrote to M...: "Since the experiments of which I wrote to you on the 9th of the preceding month, we have passed the blood of three calves into three dogs, in order to ascertain the effects which could be produced by the mixture of two very different bloods. I will let you know more about the particulars in a little while; today I will content myself with telling you that the animals in which the blood has been transfused are eating just as well as before, and that one of these three dogs, from whom so much blood had been drawn the day before that he could hardly move anymore, having received the blood of a calf the next day, he instantly regained his strength, and showed surprising vigour. We have found so many new ways of making the transfusion with ease, that Mr. Emmeretz makes a point of doing it without any ligation, with a puncture similar to that which is made in bloodletting."

"In 1668, Dr. King having drawn 49 ounces of blood from a sheep, and having given it as much blood from a calf whose jugular vein he had opened, the sheep, after the operation, appeared as strong and vigorous as before."

"The same surgeon drew 45 ounces of blood from another sheep which was smaller, and this evacuation having greatly weakened this animal, he gave it about the same amount of

calf's blood. When the wound of this sheep had been closed and untied, it no sooner felt itself at liberty than, seeing near it a spaniel, to which sheep's blood had previously been transfused, it went and gave him three or four blows with its head, and since then he has been well ever since."

The result of these experiments was that calf's blood transfused to dogs or sheep produced the best effects, and revived the animals exhausted by a heavy haemorrhage.

The transfusers of the 17th century were not content just experiment on animals, they acted on man himself.

Thus, Denys successfully transfused *three men with lamb's blood*. Richard Lower and Ed. King removed 6 or 7 ounces of blood from a man named Arthur Coga, and transfused him with 9 or 10 ounces of blood drawn from the carotid artery of a *lamb*: he was so well from this operation, that he earnestly begged that it might be done to him again.

In spite of the care I have taken to collect all the facts of transfusion mentioned at the time when this operation was so universally accepted, that is to say, from the year 1666 to the year 1668, it has been impossible for me to find a single one in which blood taken from man was communicated to man. All the successes published by the *Journal des Savants* have therefore been obtained with the help of blood *borrowed from animals of different species*.

Condemned by the famous sentence of the Châtelet (17 April 1668), transfusion fell into oblivion until 1818, when it was revived by Blundell.

The question that I am currently dealing with was taken up again, and this is how Messrs. Prévost and Dumas express themselves on the subject:

"If one takes blood and injects it into an animal of a different species, but whose globules are of the same shape, though of different dimensions, the animal is only imperfectly identified, and it can rarely be kept for more than six days."

The animals subjected to these tests exhibit some phenomena that we must not omit: the pulse becomes more rapid, the respiration retains its normal state; but the heat is lowered with remarkable rapidity when it is not artificially maintained from the moment of the operation; the droppings become mucous and bloody, and retain this character until death; the instinctive faculties are not impaired. These observations apply to the injection of fresh blood as well as to that of blood extracted twelve and even twenty-four hours ago.

If blood with circular globules is injected into a bird, the animal *usually dies* in the midst of very violent nervous accidents, comparable in rapidity to those obtained *by means of the most intense poisons*. They also manifest themselves when the subject on which one is operating has not been weakened by a noticeable loss of this fluid.

"We have transfused sheep and cow blood into cats and rabbits. Whether the operation was performed immediately after the extraction of the blood, or whether it was left in a cool place for twelve or even twenty-four hours, the animal was restored for a few days in a large number of cases."

"Sheep blood transfused into ducks excites rapid and very strong convulsions followed by death. We have often seen the animal die before the first syringe has been pushed, although it had only had a very slight bleed before, and was in very good health."

"We shall confine ourselves," say Messrs. Prévost and Dumas in conclusion, "to these few words on the question which Blundell has recently dealt with successfully, but from a point of view different from ours; and if it has been mentioned here, it is in order to prove *that transfusion on man must be abandoned as absurd and dangerous*, until we are further advanced in the full knowledge of the active principle of blood."

The conclusions of Messrs. Prévost and Dumas differ essentially from those derived from the experiments made by the first transfusers. We shall shortly indicate the cause of this difference.

Dieffenbach arrived at the same result as the experimenters of whom I have just spoken:

"I have never been perfectly successful," he says, "in reviving an animal with the blood of animals of different species. Dogs, however, were sometimes roused from their state of apparent death by the mediate transfusion of sheep or human blood, but most of them soon perished in the midst of *violent convulsions*, especially when I used human blood. None of these animals survived the sixth day. Other experimenters, however, seem to have been

happier than me. Mr. Blundell, among others, claims to have brought a dog back to life by transfusing it with blood taken from a man. The dog survived this experience perfectly.

*"As for me, despite all the precautions imaginable, I have consistently failed."*

In support of this assertion, Dieffenbach cites experiments in which human blood was injected into a cat, ox blood into a sheep and a dog: both cat and sheep succumbed. Rabbit blood was injected into a cat: the animal died the same day. Calf's blood was injected into a cat; after remaining *twenty-four hours in the air*, the cat perished. Imitating Dieffenbach, Bischoff performed *mediate* transfusion.

#### Experiments carried out by Bischoff with non-defibrinated blood.

He transfused to a young rooster, who had lost a little blood, with a quantity of this fresh *non-defibrinated* fluid, which had been taken from a cat. After a few seconds, the animal went into *violent convulsions* and died with all the *symptoms of violent narcotic poisoning*.

The same result was observed in another rooster, to whom he had transfused rabbit blood. He died immediately, although he had no haemorrhage, and the quantity of rabbit blood introduced into his venous system was not considerable.

#### Experiments carried out with defibrinated blood

Bischoff exposed the right jugular vein of a young rooster, and injected him with a small quantity of *whipped* calf's blood, which had been drawn from the carotid artery some time before. The animal did not seem to be affected by this operation and began to run around the room. No accident having occurred, he carried out the same experiment on another rooster. The vagus nerve was bound during the operation without giving rise to any accident. Both roosters survived, as well as a third, into which he injected mixed arterial and venous blood that had previously been *defibrinated*.

On 2 July 1835, he injected into the right jugular vein of a strong adult hen a fairly large quantity of *defibrinated* arterial blood, taken from a dog and heated to 36°R. The hen lost a fairly large quantity of it, but less than was injected into it. She looked weak after the operation: her breathing was calm; she soon recovered, healed perfectly, and lived until the 6 August, when Bischoff used her for another experiment.

A curious circumstance arose: the hen became wicked; she jumped in the face of anyone who approached her, and even killed a few little chickens. This wickedness diminished later, but it was not completely lost.

From all his experiments, Bischoff concludes:

1° Fresh *non-defibrinated* blood from a mammal, injected into the veins of a bird, produces death in a few seconds, causing violent phenomena similar to those observed in poisoning.

2° *Defibrinated* mammalian blood, injected into a bird, does not produce any phenomena similar to the previous ones, and the animal remains alive, without functional disturbance.

3° The property of mammalian blood to produce death in birds, which cannot arise from a mechanical obstacle to the circulation, since the globules of the former are smaller than those of the latter, and on the other hand the globules being the life-giving principle of the blood, it follows that it is the fibrin which, in consequence of its departure from the vessels, passing from the state of dissolution in which it is during life to the state of coagulum, it contains a *deleterious principle*. Therefore, as this principle has no direct effect on the restoration of life in animals of the same class, and producing fatal effects from one class to another, *it will be useful and advantageous to degenerate the blood when transfusion is desired*.

This conclusion differs, as can be seen, from that which had been formulated by Magendie on the ineffectiveness of defibrinated blood. But it is correct to say that fibrin is a toxic element; and is it not rather to the rapidity with which the blood curdles in mammals

and birds, that we must attribute the accidents observed? Are they not the result and introduction into the vessels of a *half liquid, half coagulated* blood and are we not to find in *convulsive phenomena* some traits of resemblance to those determined by embolisms?

Messrs. Prévost and Dumas, Dieffenbach and Bischoff had performed *mediate* transfusion using the syringe. The transfusers of the 17th century, on the other hand, employed *immediate* transfusion. The difference in the results obtained may have been due to the operative procedure, the latter being less exposed than the former to fibrin coagulation. Here's how I decided the question:

Experiments carried out on 26 October at the Practical School, in the laboratory of Mr, Professor LONGET.

*First experiment.* – I exposed the left crural vein of a dog, after having caused it to lose 30 grams of blood; then I discovered the jugular vein in a duck. Not having at my disposal my apparatus, which has been used for almost all my experiments, I made use of Moncocq's apparatus, which, as I have already said, fulfils the same indications.

I injected about 15 grams of *duck blood into the dog's vein*. For the first few moments, the latter animal seemed sad, collapsed and dazed. These phenomena soon dissipated, and two hours later he was in his most normal state. That same evening, he started eating again.

*Second experiment.* – To a young dog I introduced about 30 grams of duck blood by the same process. Immediately afterwards the dog appeared dazed; its anal sphincter relaxed, and the faeces escaped. In the evening, the animal ate. *The next day it retained no trace of the experience made the day before.*

Messrs. Gosselin, Ch. Robin, Lucien Corvisart, and Labbé, who had assisted me in these two experiments, observed the results I have just mentioned.

*Third experiment.* – I passed into the jugular vein of a duck from which I had lost about 40 grams of blood, 30 grams of blood taken from the jugular vein of a young dog. The duck seemed unimpressed by this operation. He is still alive today (3 November).

*It is therefore possible to transfuse to an animal of one species the blood of an animal of another species, provided that this fluid arrives in the veins of the former as it circulates in the veins of the latter, that is to say, without having undergone any beginning of coagulation.* The theory which attributes a toxic action to fibrin is based on poorly performed experiments, the defect of which depends on the mode of operation. The convulsive phenomena observed are due to an obstruction to circulation caused by the introduction of fibrinous clots, and not to a deleterious principle which would vary according to the animal species.

## CONCLUSIONS

1° An animal on the point of death from haemorrhage may be brought back to life by injecting into its veins blood taken from another animal.

2° Experience demonstrates that the globules alone enjoy this revivifying property.

3° The speed with which the blood of animals coagulates as soon as it leaves the vessels, renders the operation of transfusion by means of the ordinary injection syringe very difficult.

4° *Refrigeration* of the blood and the *deprivation of contact with air* are the two circumstances which seemed to me most likely to retard coagulation. In experiments on animals, it will be essential to observe them when mediate transfusion is to be practised.

5° Blood taken from another animal may be injected into the veins of one animal, without causing serious accidents initially, provided that the blood is perfectly liquid.

6° The phenomena observed by Prévost, Dumas, Bischoff, and Dieffenbach, in the latter case, and attributed by these physiologists to a toxic property of fibrin, are *determined solely by embolisms.*

7° By performing *immediate* transfusion, either with the aid of my device or with that of Moncocq, the formation of embolisms will easily be avoided, as my experiments show.

8° The defibrination of the blood is therefore useless, especially in man, where the blood does not begin to coagulate until four or five minutes after it has left the vessels.