

'DE TRANSFUSIONE SANGUINIS EX ANIMALI ALIO IN ALIUD'

CHAPTER 4: TRACTATUS DE CORDE (1669) BY RICHARD LOWER

A TRANSLATION BY N. PETERS

INTERPRETED BY PHIL LEAROYD

Richard Lower is universally credited with being the first person to perform a direct blood transfusion between two dogs, an experiment that was originally identified by the editor (Henry Oldenburg) of the *Philosophical Transactions of the Royal Society*. After encouragement by Robert Boyle, Richard Lower finally published his work on blood transfusion in the *Philosophical Transactions of the Royal Society* issue dated 17th December 1666. These experiments were subsequently included in Lower's book *Tractatus de corde. Item de motu & colore sanguinis et chyli in eum transitu* published in 1669, which summarises his cardiovascular and gastrointestinal research.

The book contains descriptions of Lower's experimental methods, clinical observations about heart disease, the behaviour of the pericardium, the nature and function of heart muscle and the effects of changes in blood volume on circulatory function as well as documenting his observations regarding the change in the colour of arterial blood as it passes through the lungs compared with venous blood.

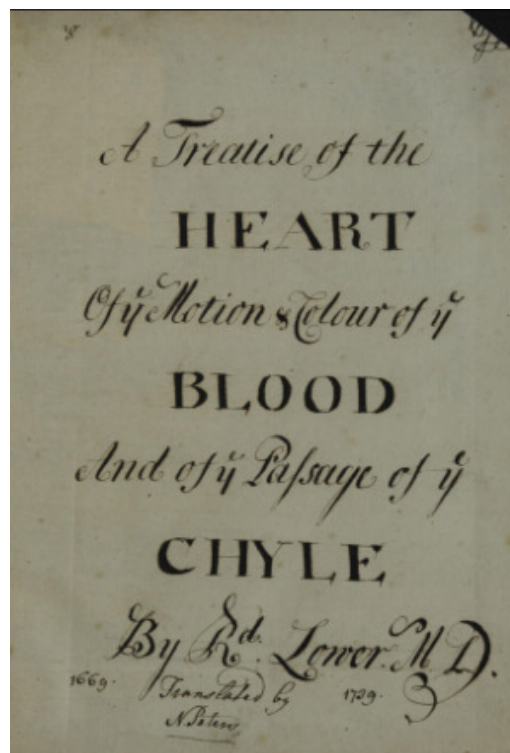
The fourth of the five chapters of the book (pages 181-192) is titled *De transfusione sanguinis ex animali alio in aliud* (i.e. 'Concerning the transfusion of blood from one animal to another'). In this chapter Lower claims priority for being the first person to perform an animal-to-animal blood transfusion and evidences this by including a letter sent to him from Robert Boyle (representing the Royal Society) on the 26th June 1666. In this letter, Boyle states that he had learned about Lower's transfusion experiments from 'Dr Wallis' (i.e. Professor Thomas Wallis who Lower worked with in Oxford) at a meeting of the Royal Society the previous week. Lower's reply to Robert Boyle, written on the 6th July 1666 is also reproduced in this chapter and it is in this letter, rather than in the text of the book itself that he identifies the method used to perform the transfusion.

The performance of a blood transfusion (i.e. a 'cross-circulation experiment') between two animals was difficult at that time because vascular access was limited by blood clotting, which Lower believed could be overcome by the use of closed / direct arterial-venous connections. The tubes that he originally used to achieve this were made from quills (probably from goose feathers) which Lower describes as being fragile and difficult to fix securely into blood vessels, invariably resulting in them having to be kept in place by hand, as well as being subject to breakage if the animals moved. In the text Lower mentions that he has developed silver pipes that are more robust and which could be more easily anchored in place by ligatures, stating '*... so that the vessels might be tied with the greater security, one of the ends is surrounded with two little rings jutting out somewhat above the surface*'. He provides an illustration of these pipes in the book ('Table 7'), showing how they are anchored in place by ligatures and how they are joined together by pieces of ox or horse artery.

As well as substantiating his priority claim and a description of the method he used to perform his dog-to-dog transfusion Lower also mentions in this chapter the transfusion of 'Mr A.C.' (i.e. Arthur Coga) who he states was '*consumed by a sort of love melancholy*' and that '*... we had resolved to repeat the experiment several times in hopes of restoring him to his right mind if he had not eluded our hopes by consulting his depressed humour rather than his own health.*' He then discusses the

types of patients who he thinks should receive a transfusion, i.e. '*... in what bodies and in what state of health chiefly this transfusion is to be attempted*'; identifying that it should not be used to treat diseases where the person's blood '*... has been a long time putrid and corrupt and very deeply imbued with a venomous ferment*', but should be used for the treatment of '*... large wounds or any other haemorrhage whatever the blood be either drawn off or lost in such a quantity as to require an immediate supply*', although he also states that people who are not diseased such as '*arthritics and maniacs whose bodies are robust*' may also benefit from a blood transfusion. He concludes the chapter on transfusion with the somewhat prophetic statement '*...Harvey first taught us that the blood circulating within its proper vessels administered life to the body, so also we first discovered that it might be transferred beyond the sphere of its own body for the health of another.*'

'N. Peters' produced an English translation of Richard Lower's book *Tractatus de corde* that was published in 1739. A copy of this book is held in the library of the Royal College of Physicians in London. It was printed in Peters' original hand-written old-English script (i.e. that variably contains the letter s written like the letter f), that contains alternative spellings and different words used at that time and includes a form of 'variable shorthand notation' used by Peters for certain words, all of which makes it difficult to read and interpret accurately. Even assuming that the translation is an accurate representation of what was originally written by Lower in Latin it is because of these problems that it is not possible to produce an exact transcript of this chapter but only an accurate interpretation. In addition, three words in the chapter are unreadable due to them being obscured or poorly written. Note: The Royal College of Physicians is unable to identify who 'N. Peters' was or why he produced the translation.



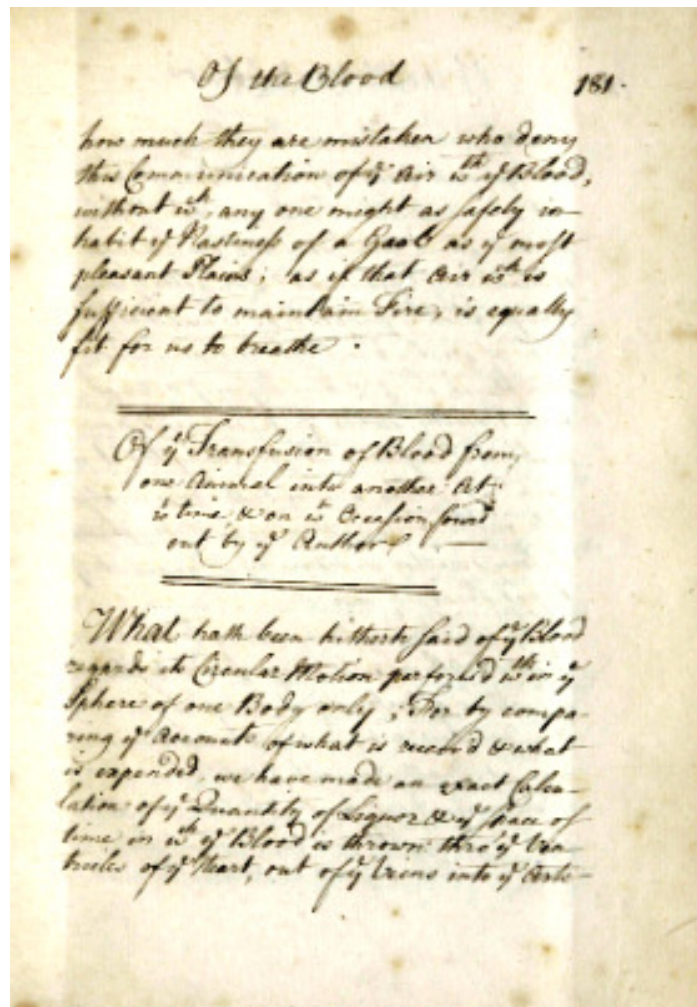
Title page of the English translation of Richard Lower's book 'Tractatus de corde' by N. Peters
(Image credit: Royal College of Physicians, London)

Tractatus de corde contains five chapters, the titles of which translated into English are:

- Chapter 1: Of the situation and structure of the heart
- Chapter 2: Of the motion of the heart
- Chapter 3: Of the motion and colour of the blood
- Chapter 4: Of the transfusion of blood
- Chapter 5: Of the chyle, its passage and change into blood

The content of Chapter 4 'Of the Transfusion of Blood' is translated to include the following topics (though these sub-headings / titles are not reproduced in the text):

By what chain of reasoning the Transfusion of Blood was first invented and by what means that brought to perfection –	182
When and by whom first attempted –	184
The occasion of publishing it –	186
A description of the whole apparatus for the transfusion –	190
In which subjects and in what state of health is it to be attempted –	200, 201



First page of Chapter 4 of the English translation of Richard Lower's book by N. Peters (Image credit: Royal College of Physicians, London)

**TRANSLATION BY N. PETERS OF CHAPTER 4 OF TRACTATUS DE CORDE
INTERPRETED BY PHIL LEAROYD**

WARNING: The content is at times very graphic with regard to how the dogs used to demonstrate the first animal-to-animal transfusions were treated – this attitude and methodology is obviously ‘of its time’. Please be aware of this and that you may find some of the details included within this translation upsetting – PL

Note: The ‘Dionysins’ / ‘Dionysius’ referred to by Lower in the text is of course Jean-Baptiste Denis who had claimed priority for performing a blood transfusion.

Of the Transfusion of Blood from one animal into another: At what time and on what occasion found out by the Author

What hath been hitherto said of the blood regards its circular motion performed within the sphere of one body only. For by comparing of accounts of what is received and what is expanded, we have made an exact calculation of the quantity of liquor and of space of time in which the blood is thrown through the ventricular of the heart, out of the veins into the arteries of the same animal. What we are now going to treat of, viz its transfusion out of one animal into another, I believe no one above three years ago ever thought of making the experiment. For after the thing was publically proposed, as what was thought to be of great life in Physic, many who were struck with the difficulty of the attempt and its novelty either quite refrained from making the experiment, or attempted it in vain. So, like one of Pythagoras’s obsolete fables, or another vain Metamorphosis, it seemed rather wished for by the ignorant and hoped for by the wise.

For these reasons I am willing to explain the whole affair as it was performed, and show by what method of reasoning it was first invented and undertaken and by what means and assistance it was at length brought to its desired issue.

It is many years since, when I saw some at Oxford, and I myself for experiment sake, injected various liquors as opiates, emetics and many such sort of medicines into the veins of living animals; the manner of doing which is now sufficiently known, and the events and consequences of each experiment is foreign to our present purpose; and when I saw if the injections of many alimentary juices as mixtures of wine and ale agreed very well with the blood of diverse animals, I was induced to try whether the blood of different animals would not equally agree amongst themselves and if it might no be mixed without any danger or torment. And because in extravasated blood the native craft and texture of the parts must needs be changed notwithstanding all the precautions that can be used to hinder its coagulation, by frequent agitation; I though it would be much better to transmit the unaltered blood of a living animal into another; which seemed very easy to be done because I had observed the motion of the blood through its [*an unreadable word*] to be so swift and rapid, yet almost its whole mass must be discharged in a few minutes. Encouraged by this, I applied myself to making the experiment.

And in the first place I endeavoured with pipes properly adjusted, to transmit it from the jugular vein of one into the jugular of another, but when I saw that the languid motion of the venous blood gave it time to coagulate in the pipe, and so obstruct its own passage, I attempted it another way and taking Nature for my pattern I was resolved to transmit it from the artery of one into the vein of the other, and by this new artifice, extend the circulation beyond its determined bounds.

When therefore I found all things answer according to expectation, I made this new and exceeding pleasant experiment at Oxford towards the latter end of February 1665 in the presence of those learned gentlemen Doctor John Wallis, Savilian

Professor of the Mathematic and Mr Thomas Millington M.D. with other noted Physicians of the same academy.

The dogs and other things being got in readiness, I drew off so much blood from the jugular vein of one of them which was of a small size till by his howling and struggling I perceived his strength was almost gone and convulsions were approaching. Then to remedy so great a loss of blood in this, by the blood of another, I introduced such a quantity out of the cervical artery of a large bulldog (which was firmly tied to the other's side) till I found by his restlessness and struggling it greatly oppressed him and that he was too full. Wherefore tying up the artery again, I again drew off the blood from the recipient dog, which was so often repeated alternately till we had exhausted the blood of two large bulldogs (the blood of both which the small dog had received). Yet this small dog, though so much blood had been drawn off and injected by turns, as would doubtless equal the whole weight of his body, as soon as his jugular vein was sewed-up and was loosed from the cords which bound him, immediately leapt down from the table, and forgetful of the injuries done him began to fawn upon his Master and tumble on the grass to clean himself from the blood; showing no more sign of concern or injury than if he had been only thrown into river.

The noise of this not long after reached London and I received a letter from the famous Mr Boyle wherein I was earnestly desired to communicate the method of the whole experiment to the Royal Society, which I did not long after, and was printed in their Philosophical Transactions, the December following 1666. The rumour of it afterwards reached foreign nations, and came to France, where being tempted by the novelty of the thing they began to pursue it with greater diligence to enlarge and illustrate it with other experiments, and what I had attempted only on brutes they accommodated to the use of mankind, as appears in their writings published the March following, 1667. And this must be said to the praise of that nation that they are always studying some way or other to improve and adorn Philosophy and Physics. But as this new invented transfusion of blood is now in the mouths of everyone and one Dionysins Professor of Philosophy and Mathematics endeavours to steal from me and arrogates to himself the invention of this noble experiment, I beg leave to insert in this place Mr Boyle's letter to me with my answer yet the reader may judge with what right or injustice he has done it.

London, 26 June 1666

Dr Sir,

I was present last Wednesday at a meeting of the Royal Society at Gresham College; where when I had learned from Dr Wallis that you had at length successfully performed (in his presence) the difficult experiment of transfusing the blood of one dog into another, I judged it well worthy the cognisance of this famous Society; wherefore I proposed if a particular relation of the experiment should be desired from that revered gentleman. The account he gave us has not a little increased your reputation in our esteem. But being asked the particulars of many things concerning such a new and unexpected attempt he said he thought it better that you should answer each of them in writing than he in words. Upon which I gave him to understand that you had some time ago promised to give me a particular account of the whole affair, if it should even answer to your expectation. Which I undertook for you would be performed and that you more fully understand that this famous Society is very solicitous of giving a more accurate account of its success. I beg that you would be so kind as to comply with this request and explain the whole method of this experiment which succeeded so happily. I am if more pressing because some ingenious and very injudicious gentlemen, not over credulous, thought it a very difficult thing, and that I had gone a little too far, when I told them what you had attempted when at Oxford, and though the experiment did not then in every respect answer your expectation for want of a proper apparatus of instruments, yet I told

them that I did not despair of your soon bringing it to perfection. I am just now called away and have feared time to beg pardon for this trouble, which I confess I was yet fonder of, because I am well assured it will not turn to your disadvantage, if on such a fortunate occasion you are brought acquainted with this famous Society where there are many who have deservedly a very great esteem and respect for you, but none more than I.

Yours most obedient
Robert Boyle

To my honoured friend
Dr Richard Lower at Oxford

Oxford, July 6 1666

Honoured Sir,

I received yours, and according to your desire shall briefly explain the whole method of transfusion in the same order as I performed it. If then you would transmit the blood of a dog or any other animal into another, whether of the same or different kind, in the first place let one of the cervical arteries be raised and when separated from the nerve of the eighth pair, let it be exposed the length of a finger. Then make a very straight and firm ligature on its superior part towards the brain, because through the whole course of the operation there is no need to slacken it. Afterwards let another ligature be made about half a finger's length lower than the other where it looks towards the heart but with such a loose knot, that it may be either straightened or slackened as there's occasion. Both ligatures being disposed after this manner and the intermediate space crossed with two other ligatures laid under the artery, open it with a lancet, and thrust a quill into the orifice towards the heart whose outer orifice is to be stopped up with a wooden peg; and the artery is to be firmly tied upon the quill by the other two ligatures.

In the other animal which is to receive the blood of the former a small part of the jugular vein about half the length of a finger is to be laid bare, at both extremities of which a ligature is to be made, but in such a manner as it may be straightened or loosened at pleasure in the interslice of these also two ligatures are to be passed under the vein, then making the incision two quills are to be inserted into the orifice, one of which looking towards the descending trunk of the vein is to receive the blood from the other dog and carry it to the heart; the other being thrust upwards towards the brain discharges the proper blood of this animal into the porringer, but both of them must be stopped up with a wooden peg and not opened until occasion is. And lastly the vein must be tied upon these quills as above.

This done, the dogs laid upon their side they are to be tied to each other as close as can conveniently be so that one of the quills may receive the other; but since the violent twisting of their necks, [*one or two unreadable words*] their being brought so close, there's need of some intermediate assistance besides the extremities of the two quills to couple them together that the blood may be transfused.

The apparatus being thus provided, two of the quills are to be unstopped; in one of the dogs that which descends along the jugular vein, in the other that which comes out of the cervical artery; after other pipes have been placed between them and adapted to each other, which I said above would be necessary in the operation, if the knots in both be slipped, which we ordered to be tied so as they might be loosened at pleasure, the blood will presently rush out impetuously in the same manner as if it flowed through a continued artery by the help of an anastomosis. As soon then as you have tied a cord around the neck of the recipient dog, as in Bleeding, or at least compressed the vein on the opposite side of the neck with your finger, let the peg in the upper quill of the jugular be pulled out, yet whilst the foreign blood is rushing in through the lower one his own may in the meantime flow out into the basins (but this must be done interchangeably at different times, having regard all along to the strength and courage of the animal) till at length the other dog expires with howlings, languors and convulsions.

This tragedy ended, let both quills be taken out of the jugular of the surviving animal, and tying the knot up tight, which before were but loosely tied let the vein be divided, which may be done without the least injury or inconvenience because there being a very large anastomosis of the jugular about the larynx, one of them is sufficient to return the blood back from the head. The vessel being divided, let the skin be sewed up, the cords untied and the dog take his leave of the table, and shaking himself a little as though just round from sleep, he marches off perhaps more brisk and lively with his brother's blood than his own.

I have only one thing more to advise you of most worthy Sir, viz, that as quills cannot be so straightly tied to the vessels or so nicely fitted to each other but yet it often happens they are loosened by the animal's struggling. I have thought it much better for the future to use silver pipes made for the purpose in their stead, and to prevent them being pulled away from the vessels into which they are inserted and that the vessels might be tied with the greater security, one of the ends is surrounded with two little rings jutting out somewhat above the surface (as Table 7, fig 1). And yet the operation might be performed without any inconvenience and the vessels be preserved from the danger of breaking by the tumbling and twisting of the animals, these pipes are to be joined by two lesser pipes to be inserted into the cervical artery taken out of a horse or an ox, all which must be joined in such a manner as to convey the blood from the immittent pipe of one side, to the recipient pipe of the other. The advantage that we receive from this intermediate artery is that it readily yields to the twisting of the animals; by its means also you may propel the blood forward if it chances to stagnate, or quite suppress it if there should be occasion. Thus Sir I have been yet more particular, because I might acquit you of your promise made for me to your illustrious Society and to satisfy them if no one can ever be more ready to obey your commands than Honoured Sir,

Your most obedient
Richard Lower

To my Honoured Sir,
Robert Boyle, London.

These letters are not published here to give any light to the method of transfusion which is now sufficiently known, but that the reader may be satisfied of the time of its invention and of its author; for the whole apparatus made for the experiment and the operation itself is so plainly exhibited in the following table it would be needless to say anything further about it.

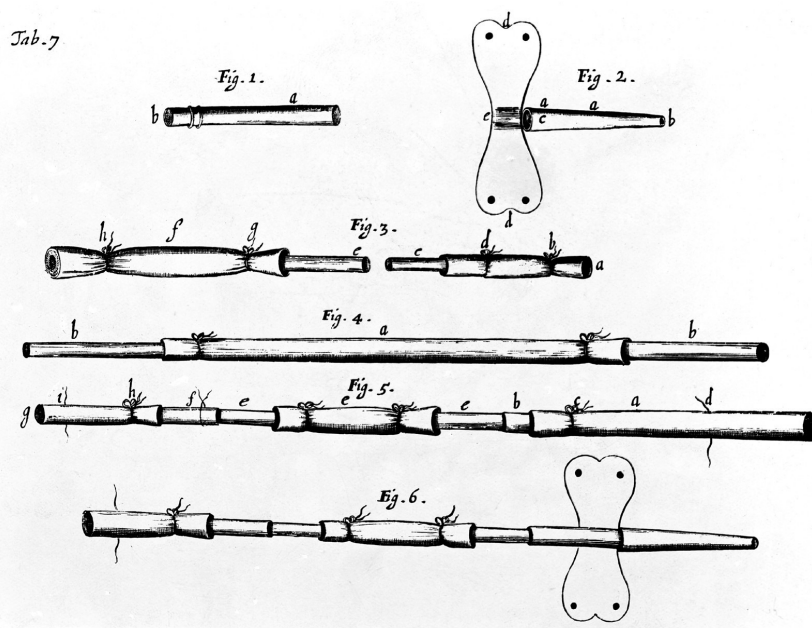


Table 7:

Fig 1: Where:

- a. Is the silver pipe.
- b. That part which is to be inserted into the vein or artery with its two circular rings where the ligature might be tied with the greater security.

Fig 2: Is a silver pipe made to convey blood into a human arm

- aa. The silver pipe.
- b. Its lesser part to be inserted into the vein of the arm.
- c. Its greater part where it receives the blood.
- dd. Its two branches perforated on both sides for passing a ligature through to fasten the plate to the arm.
- e. A sinus excavated in the middle between both branches, if it might more commodiously receive the pipe which so compresses the vein that lies under it, that no blood can flow out of it and may be fitly compared to the pit in the middle of a man's upper lip.

Fig 3: Shows the pipes as they are fitted to the artery and the vein before the operation is to be performed, where

- a. Is the emittent cervical artery.
- b. The same artery tied tight, but as a slip knot.
- c. The pipe conveyed into the artery for transmitting the blood.
- d. The place where the artery is tied tight upon the pipe between the rings.
- e. The pipe for receiving the blood and conveying it into the jugular vein.
- f. The jugular vein.
- g. The place where the vein is tied tight upon the pipe.
- h. A ligature on the vein, but with a loose knot.

Fig 4: Shows the cervical artery taken from an ox or horse and fitted to the silver pipe at both ends

- a. The cervical artery
- bb. The pipes fitted to the artery

Fig 5: Exhibits the whole apparatus for transfusing the blood out of one animal into another, where

- a. The jugular vein towards the heart of the animal into which the blood is to be transmitted.
- b. The silver pipe conveyed into the jugular vein.
- c. The vein tied upon the pipe with a close knot.
- d. A ligature on the vein beyond the pipe with a very loose knot.
- eee. The intermediate pipes and cervical artery which convey the blood from the immittent pipe into the recipient.
- f. The pipe receiving the blood from the artery.
- g. The artery of the animal which emits the blood.
- h. The place where the artery is firmly tied upon the included pipe.
- i. The place where it is tied beyond the pipe with a knot to be loose as occasion

Fig 6: Shows the same apparatus for transfusing blood from a brute into a man the use of which may be sufficiently understood from the foregoing.

Since then, towards the latter end of February 1665, this method of transfusion was first brought to perfection by me; and Mr Boyle's letter was dated the 6th of June following, and the December after my answer was printed in the Philosophical Transactions; so this Dionysius did not make the least mention of it till a full year

afterwards when he owns (though he says its what he had been thinking of for ten years past) that a transfusion of blood was possible so that he first learned by what method it might it might be done by some books of philosophy. I shall leave the world to judge to whom the invention of this experiment ought to be attributed.

But since it is the nature of some men to be pleased with nothing but what they themselves have invented and so to think no invention useful or profitable which they can't claim the authority of, it will be no manner of concern to me, as not being in the least conscious of anyone's ever having thought of the matter before, and as I am in such a particular manner honoured with the testimonies of such learned men for bringing the experiment to its perfection. In the meantime I don't at all doubt, but the invention whosoever it be, will redound to the great advantage of mankind in general, if managed with prudence and judgement.

For we can't think that the blood of other animals would be more disagreeable to the human blood than to each others as the late experiments of the French confirm, and we ourselves not long since experienced in a certain gentleman Mr. A.C. consumed by a sort of love melancholy, into whose arm we infused at several times some ounces of sheep's blood at a meeting of the Royal Society, without the least inconvenience attending it. And to carry the experiment further for his benefit we had resolved to repeat the experiment several times in hopes of restoring him to his right mind if he had not eluded our hopes by consulting his depressed humour rather than his own health.

But since the admission of foreign blood is not equally agreeable to all and there's no remedy so useful which a rash and unseasonable administration will not easily bring into disgrace, I imagine it will not be lost labour briefly to hint in what bodies and in what state of health chiefly this transfusion is to be attempted.

Those then whose blood has been a long time putrid and corrupt and very deeply imbued with a venomous ferment, cannot expect any benefit or advantage from this transfusion nor those whose viscera are touched or infected as in the scurvy, lues venerea, leprosy, poisons, or any other long and putrid disease.

For the impure blood, in its repeated passage through the viscera, fixes a stain upon them, corrupts their ferment and at length imbues them with its own nature and quality, so that if there be a substitution of new blood from any animal how sound soever, whilst it is continually circulated through the same parts it will soon contract the stain and degenerate into the same nature, as wine will soon contract the vitreous smell of a mushy cask.

Sincerum nisi vas quodcunque infundis accescit
[Unless the cup is poured everything turns sour]

But in bodies well constituted, if by unseasonable Bleedings, large wounds or any other haemorrhage whatever, the blood be either drawn off or lost in such a quantity as to require an immediate supply, I don't at all doubt that the blood of brutes may be very safely and advantageously be substituted in its room. And also in arthritics and maniacs whose bodies are robust, their viscera firm and the crisis of the brain not yet vitiated, and beside their blood uncorrupted perhaps as much benefit might be expected from the infusion of fresh blood as from the drawing off the old.

Wherefore if this noble experiment may gain more credit in the world and its advantage be more publicly known it seems to me a thing truly worthy the case of all physicians to recommend it to the whole world to be practiced whensoever there shall be occasion.

This in the mean time may be attributed to the happiness or even the praise of our own nation, that as the great Harvey first taught us that the blood circulating within its proper vessels administered life to the body, so also we first discovered that it might be transferred beyond the sphere of its own body for the health of another.

Additional Information:

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