On transfusion of blood and saline fluids / by Chas. Egerton Jennings.

TRANSFUSION

JENNINGS

THIRD EDITION

Sir Andrew Clark Bart.

With kind regards &
best wishes from
Charles Jennings

ON

TRANSFUSION

OF BLOOD AND SALINE FLUIDS.

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TRANSFUSION

OF BLOOD AND SALINE FLUIDS

BY

CHAS. EGERTON JENNINGS, F.R.C.S., M.S., M.B.,

ASSISTANT-SURGEON TO THE CANCER AND NORTH-WEST LONDON HOSPITALS.

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1888.

TO

THE RIGHT HONOURABLE THE

EARL SYDNEY, G.C.B.,

PRESIDENT OF THE CANCER HOSPITAL,

THIS WORK IS,

WITH SINCERE RESPECT,

Inscribed.

PREFACE,

By Sir Spencer Wells, Bart.,
Surgeon in Ordinary to the Queen's Household, etc.

The appearance of cholera in Egypt, and the probability that it may appear again in this country, add increased importance to any improvements made in the mode of injecting saline fluids into the veins.

Dr. Little's trials at the London Hospital encouraged me to follow his example, as Mr. Jennings has stated in the third chapter of his work; but the syringes I had at that time were far less perfect instruments than the syphon which he has devised for transfusing blood, and for injecting fluids into veins. With such a syphon I am very hopeful that this practice may be carried out without much difficulty by any careful operator—and it will be a distinct step in the advancement of Medical Science by Research if it be conclusively proved (as Mr. Jennings believes it may be) that, within certain limits, saline fluids may be safely substituted for transfused blood in the human subject—and that, by the aid of his syphon, the intravenous injection of saline fluids may be readily carried out by any qualified practitioner

alone, or the transfusion of blood with the aid of trained assistants.

On these grounds I have much pleasure in asking for the attention of the Profession to the work offered for their acceptance by Mr. Jennings.

T. SPENCER WELLS.

3, Upper Grosvenor Street, W.
July 28th, 1883.

AUTHOR'S PREFACE TO THE THIRD EDITION.

ABOUT five years have passed since it occurred to me that by attention to the physiological circumstances which retard coagulation of the blood, without acting deleteriously on its corpuscles, an apparatus might be constructed in such a manner that human blood could be directly transfused in quantity limited only by the amount the giver could afford to lose, and that such loss could be repaired by the intravenous injection of saline fluid.

Reasons are adduced in this edition not merely to prove the accuracy of this reasoning, but to show that life, jeopardised by severe hæmorrhage, can be restored even after the heart has ceased to beat, and most cases of acute anæmia can be successfully treated by injecting a moderate quantity of saline fluid into the veins.

This Research has also yielded some unexpected information upon the treatment of asphyxia, of chloroform, and of opium-poisoning; and whilst I trust I am introducing to the Profession a work which may be deemed useful, I gladly acknowledge

the varied sources from which information has been gathered for its construction.

To the few friends who have very cordially aided me I cannot feel too grateful. To Drs. FENTON-JONES, PYE-SMITH, MEARS, OLIVER, and DOVE for assistance in my earlier experiments; to Sir THOMAS CRAWFORD, Drs. OGLE and B. W. RICHARDSON, Professors RINGER and SCHÄEFER, for discussing various scientific points at length with me, I am much indebted. Professor BODDAERT-VAN-CUSTEM and his colleagues assisted me in conducting a series of experiments at Ghent, and I gratefully add that the progress of this work has been encouraged and promoted by the generous support which Sir SPENCER WELLS has afforded me whilst carrying on an inquiry into a very complicated question.

CHAS. EGERTON JENNINGS.

15, UPPER BROOK STREET,
GROSVENOR SQUARE, W.
November 7th, 1887.

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TRANSFUSION.

CHAPTER I.

INTRODUCTION.

STUDENTS, with smiling faces, are rapidly leaving the theatre of one of our metropolitan hospitals. The most brilliant operator of the day has just performed immediate transfusion with the greatest success. By means of a very beautiful instrument, the most complex and ingenious that modern science has as yet produced, a skilful surgeon has transfused half a pint, or perhaps a pint, of blood from a healthy individual to a fellow-creature profoundly collapsed from the effects of severe hæmorrhage. Some little difficulty was experienced prior to the operation, as one of the many stop-cocks of the transfusion apparatus was found to work stiffly; but this error was quickly rectified by a mechanic in attendance. Towards the close of the operation the blood-donor, a powerful and heavy young man, swooned. Two porters carried him on a stretcher into an adjoining room, his wounded arm being bandaged up, *secundum artem*, by energetic

dressers. Diffusible stimuli were exhibited by the mouth, nostrils, rectum, and skin. The man rallied in due course, being well cared for by a group of students and nurses, deputed to look after him. The wound in his arm will probably heal speedily, or a few weeks later he may possibly apply at the out-patient department of the hospital, presenting an ugly-looking pulsatile tumour, associated with a thrill and rasping bruit, connected with the vessels in the cubital triangle, a most unfortunate accident having clearly happened here, of which a record promptly appears in the columns of the *Lancet*. Time rolls on, and a spectator of the duplex operation, possessed of an instrument such as he had seen employed, finds himself at midnight, in a lone house in the country, face to face with an alarming case of post-partum hæmorrhage. He has adopted the modes of treatment recognised as judicious for the condition before him. He has employed active hæmostatic agents, and finally that potent but highly dangerous styptic perchloride of iron. His patient is blanched and collapsed to the last degree. Are not her bloodvessels so thoroughly drained of blood, that there is not sufficient of that element circulating in the uterine walls to stimulate to *permanent* contraction its muscle fibres? Is not this the very case for transfusion? The accoucheur puts his apparatus in order (he may not have it with him, and be obliged to send home for it), and selects a blood-donor. He has little time or opportunity, under the circumstances I have depicted, to find an

adolescent, healthy beyond a doubt; little time has he to eliminate the existence of syphilis or of other specific communicable diseases by a well-planned examination of the youth, or to obtain a knowledge of his previous history and mode of life. The operation is commenced; the blood-donor faints; the friends of the patient, the necessarily improvised assistants to the accoucheur, faint also. The operation is abandoned, and it and he who proposed it fall into disrepute. But there may fortunately have been time to summon a skilled assistant. The veins, both of blood-giver and recipient, may have been dexterously opened, and transfusion commenced. Still accidents may even now happen: a small coagulum may form within the apparatus, or a little air gain access through some contingency to the veins operated on.

The picture is carried far enough. Is the operation of immediate transfusion, as taught and elaborately performed in hospital practice, where there is every means of ensuring success, one of universal application? Is it one that can always be performed when most needed—under urgent circumstances and at a moment's notice, often in the night, at Land's End, John o'Groat's House, or Ratcliff Highway, and by an unaided operator, with everything against him?*

It is in obstetric practice that the operation is most frequently demanded; there are numbers of cases on

* Jennings. *Lancet*, 1882, vol. ii. pp. 485, 486.

record where a precious life has been snatched from destruction beyond all question by a timely transfusion; there are many where the patients were positively *in articulo mortis* when the operation was commenced—cases in which the fresh lease of life can be fairly attributed to transfusion and to nothing else; more still there are, unfortunately, where women in childbed have succumbed to hæmorrhage, without this, the sole chance of salvation, having been extended to them.

Can the profoundest sceptic or the greatest therapeutic Nihilist of the age dispute the veracity of these assertions? Ought not a death from ante-partum or post-partum hæmorrhage to be regarded as a blot on the escutcheon of British Midwifery?

The sceptic retorts that there are doubtless not a few cases where transfusion has proved fatal. Have not patients expired during the operation with all the manifestations of air in the veins? Has not an autopsy sometimes revealed pulmonary embolism and thrombosis? Is not transfusion, especially the immediate method, altogether too grave a procedure to be undertaken by a practitioner single-handed? Away, thou *bête noir!* Utter not such remarks among thy *confrères!* Speak not thus before the learned societies where the *savants* do congregate! If the parturient woman did expire suddenly whilst transfusion was in progress, was not her uterus also being injected with hot water to check the hæmorrhage, and may not air have readily gained access to the venous

system *viâ* the uterine sinuses *vice* the vein of the arm ?

If she died from embolism, was not a styptic injection of perchloride of iron employed, and the embolus produced thereby, and not from any fibrination in the transfusion apparatus, as thy malevolence suggesteth ? The critic is silenced, but not convinced.

Due importance must, however, be attached to these practical, well-founded, and just objections. To elevate transfusion from its theoretical position in the Healing Art, and from its doubtful value in Medicine as a therapeutic measure, the operation must be simplified. As a rule blood-transfusion should be dispensed with, and an artificial substitute found. All complex instruments must be abandoned, and a method devoid of danger and of easy application employed. Then, indeed, will physicians rejoice in a considerable increase to their territory, and surgeons in the addition of an important item to their list of conservative operations.

This train of thought forced itself upon me very strongly when in a case I have recorded,* and to which I shall refer hereafter, I injected sixteen ounces of a saline alcoholic fluid into the median basilic vein of a patient of the London Hospital Maternity Charity, for severe ante-partum hæmorrhage, with the best result; adopting this method not by election, but by compulsion, for although in London and on a Sunday

* Page 25.

afternoon, I was unable to procure a blood-giver at a moment's notice.

From reading the literature on the subject, I believe that this method merits the highest commendation, and as far as our knowledge goes, outstrips all others in point of efficacy, safety, and ease of application. With the view of promoting still further these desirable objects, I have devised a syphon for intra-venous injection and a modified form of cannula, in order to secure the advantages and to discard the objections which the apparatus for transfusion possess.

Having published this method in the journals, and having demonstrated it before many of the leading scientific societies in this country, it has been suggested to me to write a small monograph, combining the opinions I entertain in a *résumé* of "Transfusion;" hence the appearance of this short essay.

Yet one word more. Since transfusion is so often called for in Midwifery for ante-partum and post-partum hæmorrhage, and to ensure success the operation is an important, though by no means the *sole* part of the treatment which must be adopted; and since obstetricians hold very diverse opinions as to the proper *modus operandi* for this class of cases, I consider it quite within my province to dilate on this topic freely; and having formed my conclusions thereon after careful deliberation, and some experience of these hæmorrhages, I may perhaps be pardoned if I advance my views somewhat dog-

matically, and criticize keenly, though temperately, those of others.

It cannot be of practical utility to produce statistics of all the cases of transfusion recorded up to the present time; but it will probably be advantageous to select examples — some successful, others unsuccessful, and endeavour to show the causes of the results obtained—that some definite ideas may be derived therefrom as to the indications and most suitable methods for transfusion, and as these few pages are written apart from the bias of pre-formed opinion, the reasons *pro* and *con* will be impartially, though perhaps imperfectly, set forward.

CHAPTER II.

ITS HISTORY.

THAT empirical treatment is so often adopted before a rational basis is known, is well exemplified in transfusion; for whilst the work *De motu cordis et sanguinis in animalibus* of the immortal Harvey appeared in 1628, transfusion was *attempted* at least as early as 1492.* I say *attempted*, for the operation proved a complete failure:

"The vital powers of Innocent VIII. rapidly gave way; he had for some time fallen into a kind of somnolency, which was sometimes so profound that the whole Court believed him to be dead. All means to awaken the exhausted vitality had been resorted to in vain, when a Jew doctor proposed to do so by the transfusion, by a new instrument, of the blood of a young person, an experiment that had hitherto only been made on animals. Accordingly, the blood of the decrepit old pontiff was passed into the veins of a youth, whose blood was transferred into those of the old man. The experiment was tried three times, and at the cost of the lives of the three boys, pro-

* *Cf.* Ogle, *Harveian Oration*, 1880, pp. 29, 107, *et seq.*

bably from air getting into their veins, but without any effect to save that of the Pope." *

Surely such a record "points a moral, and adorns a tale;" it would, however, be most unfair for us whose physiological, pathological, and therapeutic knowledge has been in great part derived from the errors and mishaps of those who have preceded us—errors which, though perfectly justifiable in them, would be quite inexcusable in us—to criticize unduly the first endeavours made nearly four hundred years ago to perform an operation which even now, for its accomplishment, requires not only knowledge, but skill, deliberation, and decision.

Harvey's discovery of the circulation, in the seventeenth century, was followed by Lower's demonstration in this country in 1665 of a case of immediate transfusion in the dog.

"First, Take up the *Carotidal* Arterie of the Dog, or other Animal, whose Bloud is to be transfused into another of the same or a different kind, and separate it from the Nerve of the Eighth pair, and lay it bare above an inch. Then make a strong Ligature on the *upper* part of the Arterie, not to be untied again: but an inch below, *videl.* towards the Heart, make another ligature of a running knot, which may be loosened or fastened as there shall be occasion. Having made these two knots, draw two threads under the Arterie between the two ligatures; and then open the Arterie, and put in a Quill, and tie the Arterie upon the Quill

* Villari, "Life of Savonarola." Cf. *Medical Times and Gazette*, 1865, vol. ii. p. 81.

very fast by those two threads, and stop the Quill with a stick. After this make bare the *Jugular* vein in the other Dog about an inch and a half long, and at each end make a ligature with a running knot, and in the space betwixt the two running knots draw under the Vein two threads, as in the other: then make an Incision in the vein, and put into it two Quills, one into the *descendent* part of the vein, to receive the bloud from the other dog and carry it to the Heart; and the other Quill put into the other part of the *Jugular* Vein which comes from the Head (out of which, the second Dog's own bloud must run into Dishes). These two Quills being put in and tyed fast, stop them with a stick, till there be occasion to open them.

"All things being thus prepar'd, the dogs on their sides towards one another so conveniently, that the Quill may go into each other (for the Dogs' necks cannot be brought so near, but that you must put two or three several Quills more into the first two to convey the bloud from one to another). After that unstop the Quill that goes down into the first dog's *Jugular* vein, and the other Quill coming out of the other Dog's Artery; and by the help of two or three other Quills put into each other, according as there shall be occasion, insert them into one another. Then slip the running knots, and immediately the bloud runs through the Quills, as through an Arterie, very impetuously. And immediately as the bloud runs into the Dog, unstop the other Quill, coming out of the *upper*

part of his *Jugular* vein (a ligature being first made about his neck, or else his other *Jugular* vein being compressed by ones Finger); and let his own bloud run out at the same time into Dishes (yet not constantly, but according as you perceive him able to bear it) till the other Dog begin to cry, and faint, and fall into Convulsions, and at last dye by his side."*

Though transfusion was first performed on animals in England by Lower in 1665, the method was previously conceived in France in 1651.

At a meeting of one of the learned societies held at Paris in July, 1658, there were present, among others, the following distinguished personages: Jean Denis, a professor of mathematics and philosophy; Paul Emmerez, a skilled surgeon; Claude Tardy, physician to the Duc d'Orleans; and Robert des Gabets, a monk of the Benedictine Order.

Des Gabets, on being asked to speak, astonished the audience by annunciating some marvellous ideas which he had for a long time pondered over. Referring to the then recent discovery of the *circulation* by Harvey, he felt convinced that he could establish another movement of the blood, *communication*, by which he meant "the efficient passage of the blood of a healthy man or other animal to the veins of an individual weak or diseased." A friar, Eloy Pichot, had made for Des Gabets, seven years previously, an instrument consisting of two small silver cannulæ,

* *Philosophical Transactions*, Monday, Dec. 17, 1666, p. 353, *et seq.*

connected by a leather purse about the size of a walnut, the cannulæ being each guarded at one end by a valve, so that, by pressing gently with two fingers on the purse, the blood, in its transit, could not return into the emittent, but would be forced onwards into the afferent vein. "The purse has the additional advantage of estimating the quantity of blood communicated."

In a letter written by Jean Denis (dated March 2nd, 1668) to M. Sorbière, the former vindicates the honour of France in regard to this splendid discovery, and asserts that some English noblemen, who were present at Des Gabets' demonstration of it, were much interested, so that it was not to be wondered that the discovery should pass from France to other countries. "It is indisputable," continues Denis, "that the English merit the honour of having profited by the idea the French have neglected, they" (the English) "having first practised the operation on dogs with success. But it must be conceded that it was in France that the method was first originated."

In March, 1667, Denis and Emmerez publicly transfused from dog to dog. The experiment was varied and repeated *ad infinitum*. Sometimes blood was transfused from artery to artery, sometimes from vein to vein, from artery to vein, or again from vein to artery, the operations not being followed by fatal results. The system of transfusion was developed a stage further a few days later, for Denis and Emmerez transfused from a calf to a dog. At length,

on June 15th, 1667, Denis and Emmerez essayed transfusion on man. The operation was performed on the person of a youth, *æt.* fifteen or sixteen, "who had been tormented for more than two months with an intractable and violent fever." The historian does not exactly state what the indications for the operation were, but complete success attended the transfusion of nine ounces of blood from the carotid of a lamb to the vein of the young man's arm.

On Nov. 23rd, 1667, the English performed transfusion for the first time on a human being. Nine or ten ounces of blood, supplied from the carotid of a lamb, were transferred into the veins of the arm of one Coga.*

An unfortunate man, Antoine Mauroy, aged thirty-four, who had been imbecile since the age of seven or eight, and who lived a few leagues from Paris, was wont to appear in that capital and amuse the juvenile portion of the populace with his eccentricities. His last extravagance was to escape one day from his wife's control, and parade the streets of Paris, clothed only in nature's garb, followed by an admiring throng. Such an opportunity was not to be lost. Is there not a proverb, '*Fiat experimentum in corpore vili*'? The enthusiastic Denis pounced upon this luckless wight, finding him in the Marais du Temple, "half covered with old rags, girt with many bands of straw, without shirt or drawers, without breeches or shoes, the face bedaubed with charcoal, and followed in this plight

* *Philosophical Transactions*, Dec. 9th, 1667 (No. 30), p. 557.

by a crowd of children, who were running after him."

On December 19th, 1667, at 6 p.m., Emmerez laid bare the crural artery of a calf, and drew 10 ounces of blood from a vein of the fool's right arm, substituting for it 5 or 6 ounces derived from the calf.

Two days later, the operation was repeated; now only 2 or 3 ounces were abstracted, but nearly a litre of calf's arterial blood was transferred.

Two days later still, with the view of transfusing more blood, a cannula was inserted into a vein of the man's arm, blood being drawn simultaneously (for this was considered indispensable) from a vein of the leg. As the flow of blood was bad, the operation was abandoned; the man died the same evening.

The record of this case is not sufficiently explicit to justify any deductions therefrom; nevertheless I shall bring evidence to show* that the introduction of alien corpuscles into the vascular system is always dangerous, and if the quantity so introduced be large, fatal. There is, I think, every probability that this madman might have survived the first transfusion ("five or six ounces"), but that "nearly a litre" of calf's blood, the quantity transfused at the second operation, proved a mortal dose.

The reader will not be surprised to hear that the enemies of transfusion, who were numerous, most unmercifully attacked the poor experimentalists. The Faculty of Medicine at Paris, who, we are told, was

* Chapter III.

opposed to every kind of progress, who still refused to recognise the Harveian circulation, who had rejected antimony and quinine, but had contented themselves with the Hippocratic physiology—who had beheld with anguish science drawn beyond their school, and believed themselves to be the everlasting depository of medical lore—this Faculty, without directly meddling in the matter, subtly set many of its members to work, who anonymously published pamphlets against Denis and Emmerez.

These physicians are even accused of having bribed the widow of the unfortunate lunatic to charge the operators with the death of her husband. The scandal assumed colossal proportions. The widow Mauroy, goaded by cupidity rather than marital affection, pressed the matter with such assiduity that Denis, in self-defence, lodged a complaint against the widow and those who supported her, in court. Denis appeared as the plaintiff, and not as the defendant, as commonly reported.

The court, whose jurisdiction extended alike over civil and criminal matters, prohibited the performance of the operation in future, save with the sanction of the Faculty of Medicine.*

Various apparatus† have been proposed for immediate transfusion. Denis's cannulæ have already been described. Boehm connected them with a small piece of intestine, as, for instance, that of a fowl, by

* S. Chereau, *L'Union Médicale*, Sept. 8, 1874, p. 373, *et seq.*

† This description is borrowed largely from South's *Chelius*, vol. ii. p. 877, *et seq.*

stroking which the passage of the blood might be encouraged. Instead of intestine, Regner de Graaf connected the two tubes with a piece of artery dissected from a beast, to which there was a side branch, partly to allow the escape of the air, and partly to note the constant stream of the outflowing blood. Von Graefe's apparatus consisted of a glass cylinder filled with warm water at a temperature of 97° F., and furnished with a cock for the escape and renewal of the water, and through which a glass tube passes for carrying the blood; this tube joining at one end another, curved and shouldered, for insertion into the artery of a beast, and at the other an elastic tube to be attached to the cannulæ already inserted into the patient's vein.

"Infusion, in contradistinction to transfusion, mentioned by Magnus Pegelius and Libavius in 1615, and practised on a dog by a Captain G. von Wahrendoroff in 1642, was first subjected by Ch. Wren, who first performed it on a malefactor in 1656, to philosophical examination. The English physicians Clark, Lower, and others, made experiments with it upon brutes; Major, in 1664, and Elsholz, in 1665, first employed it on men; Schmidt, Purmann, and V. Sarpi especially occupied themselves with it. However, it soon sank in the estimation of physicians, and has only of later years been employed in a few cases in Germany by Köhler, Hemran, Meckel, and others. After the early cases and his own experiments in Germany by Graefe and Horn, and by Laurent and

Peray in France on men, Bichat, Nysten, Seiler, Magendie, Orfila, and Dieffenbach instituted some exceedingly interesting and, for physiology, important experiments upon the injection of different kinds of matters into brutes, and have employed this operation on man, as, for instance, in tetanus and cholera."

In stubborn nervous diseases, such as epilepsy, affections of the mind, hysteria ; in dyscrasic diseases, syphilis, gout, obstinate diseases of the skin; in typhus and intermittent fevers, infusion has been tried, and very different remedies have been injected. Narcotic remedies, as belladonna, opium, hyoscyamus, stramonium, and also digitalis and strychnine, have generally dared only to be given in two-thirds of their ordinary dose ; salt is borne in large quantity. "They have the same effect as if taken into the stomach, though their operation is mostly very irregular."

Early in this century* Dr. Blundell increased the knowledge on the subject of transfusion by means of many experiments on dogs.

These experiments not merely corroborated those already made by others as to the success of direct and indirect transfusion between animals of the same species, but also conclusively proved that so far as lower animals are concerned at least, it is an unsound and dangerous practice to transfuse alien blood.

Dr. Blundell's transfusion apparatus or "gravitater"

* *Transactions of the Royal Medical and Chirurgical Society*, vol. ix. p. 56, *et seq.*

consisted of four different parts : the syringe, the cup, the tubes, and the frame.

I choose to refer the reader to the original record rather than give an exact description of this useful, but complicated, machine.

In late years the methods for transfusion have been much perfected by the labours of many eminent men.

It is beyond the scope of this small treatise to attempt to describe or even enumerate all these methods, for their name is legion ; but perhaps at the present time the instruments most generally known and used are those of Roussel, Aveling, Hewitt, Little, Hamilton, Hicks, MacDonnell, Hime, and Monocq. The object of the following pages will be to endeavour to point out the strong and weak points in these various forms of apparatus, which they in common with every other surgical instrument must possess, in the earnest hope that by such a criticism, conducted in the spirit of investigation, some practical deductions may be derived and possibly prove hereafter of service to mankind.

CHAPTER III.

ITS PROSPECTS AND ITS INDICATIONS.

By combining the tables given by Bellina, Aschè, and Leisrink we get a total of 243 cases in which transfusion was performed for acute or chronic anæmia prior to the year 1873. Of these 243 cases, 143 (46·9 per cent.) terminated in complete recovery; in 34 cases (14 per cent.) the operation was followed by temporary benefit, but failed to save life; in 95 cases (39·1 per cent.) no beneficial result whatever was achieved. Accordingly, transfusion failed in a little over a third of all these cases, while in nearly two-thirds of the total number it was followed by improvement or recovery. These figures would suffice as they stand to justify the operation, even if we did not know that it had almost invariably been resorted to in desperate cases. If we examine more closely into the details of each failure, we find that in a vast majority of them death cannot be ascribed directly or indirectly to the operation, but was due to other causes. An accurate sifting of these cases is, however, impracticable, for the estimate of the

probable duration of the patient's life in each case, supposing transfusion not to have been performed, would be too much at the mercy of the individual judgment of the critic. I may therefore leave the reader to consult the original records for himself, and arrive at an independent opinion on the subject.

In 113 of the cases alluded to above the operation was performed on account of hæmorrhage during or immediately after delivery. Of these 113 cases 67 ended in complete recovery, 7 showed only a temporary improvement, while 39 terminated fatally, without any sign of previous amendment. A positive result was thus achieved in 65·5 per cent., or two-thirds of all the cases belonging to this category. Of this proportion 59·7 per cent. were recoveries, while in only 6·2 per cent. was the improvement temporary. As the recoveries amount to more than half of the total number of cases, the obstetrician must consider transfusion obligatory whenever acute anæmia of sufficient severity to threaten life sets in as a result of hæmorrhage during delivery, the hæmorrhage itself having been arrested.*

If further evidence be needed in favour of the prospect of success which may be anticipated from transfusion, let me quote Roussel's experience :

"Table of 50 direct transfusions, performed by Dr. J. Roussel, from 1865-1877. Subjects, 37 men, 12 women, and 1 child. Results, 26 complete recoveries,

* *Cf.* Ziemssen, *Cyclopædia of the Practice of Medicine*, xvi. p. 477.

14 partial successes, 10 unsuccessful, in every case after some amelioration."*

From a close scrutiny of the splendid series of cases of which this paragraph forms the heading—a series of cases in which, like those reported by Bellina! Asché, and Leisrink, the operation was performed for all "sorts and conditions of men," both in hospital and in private practice, as well as from careful observation of those cases of transfusion I have witnessed at the London Hospital, I submit the following propositions :

1. That the direct method is only applicable to a few out of the many cases in which transfusion is demanded, and, as a rule, should only be attempted by a skilled surgeon, with skilled assistance and hospital appliances at his disposal.

2. Saving the possibility of accidents, transfusion, when properly performed, is most successful in those cases of severe hæmorrhage, unaccompanied by shock (or the shock, if present, being consecutive to the hæmorrhage), in which the bleeding can be checked.

3. No *permanent* benefit can be anticipated from the operation in those cases where shock is present, as, for instance, after amputation at the hip.

4. It is also useless for small repeated hæmorrhages, unless the cause of those hæmorrhages be removable, as in a case of retained placenta.

5. The immediate causes of failure are these : 1st

* Roussel, *Transfusion of Human Blood* (English Translation), p. 89.

the entrance of air to the vein operated on; 2nd, coagulation of the blood; 3rd, the introduction into the vascular system of fluids which act deleteriously on the blood; 4th, the complexity of the method employed, and the impossibility of always procuring skilled assistance when required.

6. Saving these causes of failure, *which can all be obviated*, the dangers of the operation, *per se*, are small, and are not greater than those which attend venesection and other minor operations on the venous system.

Ample proof is afforded by means of experiments which have been made on the veins of dogs* that these vessels will readily tolerate operative procedures. If corroboration be needed, the many successful cases of phlebectomy recorded, as well as the success which usually follows operations for varicocele and hæmorrhoids, prove that operations on veins of small and medium size are usually attended with but little danger.

It is for ante-partum and post-partum hæmorrhage that transfusion is most frequently and most imperatively demanded; and as the treatment which should be pursued for these dangerous conditions is still unsettled, and not by any means so clearly stereotyped as is that for those kinds of hæmorrhage which come under the surgeon's notice, I quote, by way of comparison, two cases.

CASE No. I.—Mrs. A——, *æt.* 38, mother of

* Callender, *Holmes' System of Surgery*, 1870, vol. iii. p. 358.

six children.* She had been in poor circumstances lately. She was nearly at full term of pregnancy. While at a neighbour's house, she was noticed hysterically laughing, and then to be confused in mind for a few minutes. A large pool of blood was found beneath her; she moved about the room, making three pools of blood; she was ghastly pale, and was taken home, where another pool of blood was found on the floor. She was placed in bed, and my clerk, Mr. Booth, found her pulseless; the os uteri was the size of a crown-piece. She continued pulseless an hour, when there was some slight attempt at reaction, and the pulse could be felt as a fine thread, beating 120 p.m. Two hours after the attack I saw her. There had been but little loss since. The os was the size of a crown-piece, but not dilatable. Her depression was so great, that the examination caused a marked subsidence of the pulse. I ruptured the membranes and gave stimulants freely. The surface was cold, and warmth was applied without result. However, after four or five hours the face regained its colour, and the pulse somewhat improved in volume. There was no hæmorrhage going on externally or internally, as far as could be ascertained. A dose of secale was given to hasten uterine action. Vomiting followed with increased frequency of pulse, which was now beating at 130-140 p.m. In another hour a marked depression of power of pulse again

* Braxton-Hicks, *Guy's Hospital Reports*, 3rd series, vol. xiv. 1869, pp. 8, 9.

ensued, with jactitation and attempts to rise, the expression of face was drawn, and the breath cold ; once the pulse vanished for some time.

I therefore transfused, taking blood from the husband. Six ounces were injected, the result being very marked. For the pulse, from being almost imperceptible, became quite distinct ; the jactitation diminished ; the breathing steady and quiet. The difficulty of operating was very great, owing to the almost complete absence of domestic appliances.

A slight increase of blood loss again occurring, I thought it best to complete delivery as soon as it could be effected consistently with the safety of the patient. I found the uterus in moderate action, and os fully expanded. I therefore applied the long forceps, but owing to the fatty state of the lower part of the uterus, it was somewhat difficult to pass the lower blade. I therefore removed it, and employed combined internal and external version, by which the child was turned easily in a minute, and then *gently drew down* the child, the uterus contracting after it. But after the whole ovum had been expelled *the uterus ceased to contract.* Some slight bleeding ensued ; I passed my hand into the uterus, cold water was injected into its cavity, but she was reduced to the last stage. She lingered on some little time during which I made another attempt to transfuse, but as the supply of blood was very slow, coagulation interfered, and practically only a very small quantity entered the veins. She shortly after died, about ten

hours after the first occurrence of the hæmorrhage. The process of delivery in these cases of extreme exhaustion is very depressing, and adds enormously to the risks of the case.

The cause of failure appears to lie in the words I have italicized. Dr. Braxton-Hicks does not say he *expressed* the child, and after delivery the uterus *ceased to contract.* The sequence of events was as follows :

From the profound loss of blood, the uterus was in an atonic condition, so that it could not contract to expel the child. The tone of the uterus was in some measure restored by transfusion, but *not to an extent sufficient* to warrant the obstetrician in emptying the organ, with the *rapidity* which the description of the case implies. Hence the cause of the post-partum hæmorrhage.

CASE NO. II. — On August 20th,* at about 3 p.m., M. A. S——, a patient of the London Hospital Maternity Charity, pregnant and nearly at term, fell in the courtyard adjoining her house, suddenly becoming the subject of profuse ante-partum hæmorrhage. At 5 p.m., I found her collapsed to a marked extent, lying on a sofa in her bedroom, the pulse barely perceptible, the skin cold and clammy, extreme pallor of the face, an anxious expression of countenance, sighing respiration, and slight jactitation. Blood was flowing from the vagina ; the mucous membranes were blanched. Upon examination, I

* Jennings, *Lancet*, 1882, vol. ii. p. 436.

found the os uteri fairly dilated, the right shoulder presenting; the membranes were unruptured, and the edge of the placenta could be felt just within the os uteri posteriorly.

At this critical juncture I remembered the cardinal rules laid down very clearly by Dr. Palfrey for the management of cases of this description—viz., to arrest hæmorrhage, to correct the malpresentation with the least possible shock, and by cautiously employing stimulants and restoratives freely, to *allow the patient to rally and deliver herself spontaneously*. A drachm of brandy with one of water was injected into the gluteal muscles; the membranes were ruptured, and the left leg brought down into the vagina with considerable ease, owing to the flaccid condition of the parts and the amount of general anæsthesia present. The abdomen was kneaded, the hæmorrhage ceasing. To have accelerated delivery at this period would, I think, have proved fatal. Two grains of sclerotic acid, in solution, were injected into the buttock, and the woman was covered with blankets. I left an assistant steadily kneading the uterus, and returned to the hospital for a transfusion-apparatus. Not being able to procure a blood-giver, it was determined to try a saline alcoholic intra-venous injection.

I may here observe parenthetically that great difficulty was experienced in finding a vein, owing to the profound anæmia existing. The patient's right elbow was immersed in hot water, and the cubital

triangle thoroughly sponged. These means, added to friction of the part and the adaptation of a turn of a bandage around the arm, were successful in causing the veins to stand out with some prominence; an incision was made over the median basilic, the vein exposed, isolated, and an aneurism-needle armed with a double ligature passed beneath it. The distal ligature was tied, the vein opened, the nozzle of a three-ounce metal syringe, charged with the fluid already prepared, inserted, the proximal ligature tied loosely over the nozzle of the syringe, and the piston pressed slowly home. This was about 6 p.m., the woman being moribund. The syringe was emptied; it was disconnected, refilled, and readjusted, the process being continued till sixteen ounces of the fluid had been injected. Signs of animation very rapidly appeared—recognition of people present, speech, vision, and hearing returned, and complaints of pain in the abdominal region were made. The syringe was withdrawn, the proximal ligature on the vein now tied tightly, the wound closed with the interrupted suture, and a compress and bandage applied. Another grain of sclerotic acid was injected hypodermically, and the case left to nature, delivery occurring at about 7.30 p.m., without *any further operative interference whatever.*

These cases I have narrated merely as good examples of the effects of two essentially different kinds of treatment, nor are they by any means the

sole examples which could be adduced: I feel convinced that for ante-partum hæmorrhage, whether prævial or accidental, as a broad rule, subject to very few exceptions, the plan of treatment advocated by Dr. Palfrey, though antagonistic to the views of many, is, inasmuch as it is the most successful, certainly the best.

In ante-partum hæmorrhage it is usually an easy matter to draw down a fœtal leg into the vagina, for this simple manœuvre is greatly favoured by the flaccidity of the soft parts, resulting from the sérious hæmorrhage, to prevent the persistence of which this line of action is demanded.

This effected, the liquor amnii readily escapes, and the smooth, globular fœtal head becomes opposed to the fundus uteri, the child forming a tampon of no small efficacy, besides being at once a *point d'appui* for the uterus to be stimulated to contract upon, by means of manual excitation, the subcutaneous injection of oxytoxics, and the exhibition of restoratives; and what restorative can compare with transfusion? The obstetrician's work now ceases: he need no longer be the skilled physician, but should become the patient nurse.

The only conceivable advantage in completing delivery *artificially* at this period is the possibility of saving the life of the child, but it must be remembered that when the interests of the child are opposed to those of the mother, it is almost universally admitted that the welfare of the latter rather than of the former should be considered; nor must it be

forgotten that even under the most favourable circumstances, attempts to save the offspring will be probably futile, for it is nearly always premature, and often dead before the accoucheur's arrival.

Is not the rapid removal of the child by operative proceedings in obstructed labour one of the most active predisponents to post-partum hæmorrhage? Is not this danger, *à fortiori*, very greatly increased where the uterus is atonic as the result of acute anæmia? But if time be allowed for the uterus, stimulated by transfusion, to regain its contractility to an extent sufficient to expel the fœtus, there is every hope that with the careful management of the third stage of labour, sound contraction of the uterus will be ensured and avert a fatal hæmorrhage.

"In cases of hæmorrhage," writes Dr. Barnes, "during and after labour, it has been apprehended that the new blood transfused might again escape on the uterine surface. This source of failure may be overcome by the local application of perchloride of iron."*

"One more emphatic reason I would plead in favour of the early resort to this treatment" (*i.e.*, the injection of perchloride of iron) "is, that it is not enough to save bare life; we must save all the blood we can. For this reason, and having acquired confidence in the efficacy and safety of this crowning remedy, I never now lose time by persisting in other means that may fail, and which, having failed even partially, leave the patient the worse by the quantity of blood lost."†

* Barnes, *Obstetric Operations*, p. 584. † *Ibid.* p. 559.

"The first idea of using this means in uterine hæmorrhage was suggested to my mind on reading that perchloride of iron had been injected into an aneurismal sac."*

But it must be confessed that this treatment for aneurism is a dangerous one, and one only to be adopted where other recognised methods are impracticable. The parallel, moreover, is hardly just, for in the case of the aneurism, the vessels leading from it may often be compressed whilst the injection of the styptic is being carried out—a precaution inapplicable to the uterine vessels.

All will concur with Dr. Barnes as to the absolute and urgent necessity of checking the flow of blood from the uterus before resorting to transfusion, though it must be admitted that the abrupt introduction into the vascular system of a quantity of fluid, which, circulating amongst the uterine muscle-fibres, excites them to contractility, is in itself a powerful hæmostatic. I venture to dissent from this eminent physician as to the safety of the intra-uterine injection of perchloride of iron, and am disposed to believe that the use of this styptic is inadmissible in all save a few exceptional cases. Dr. Barnes admits that disastrous accidents have followed the subcutaneous injection of solutions of this salt into nævi. He even refers to many fatal cases. Is perchloride of iron less prone to cause coagulation of the blood in the patent uterine sinuses than of that in a nævus? Will not ice—a

* Barnes, *Obstetric Operations*, p. 544.

remedy nearly devoid of danger—compete most favourably with perchloride of iron as a hæmostatic? I can call to mind cases in which the former has succeeded in arresting hæmorrhage where the latter has failed. Never have I ever had any anxiety from the use of ice, but have had reason to regret when, following the custom of the day, I have resorted to perchloride of iron.

How many cases are recorded, and how many are not recorded, in which the patients have died whilst the nozzle of the injecting syringe was actually *in utero?* And are we always to believe they have succumbed to hæmorrhage, and not to embolism, the styptic solution having been employed all too late?

"Mr. Kesteven relates a case (*Lancet*, 1874) in which a child died suddenly after he had injected five minims into a nævus on the head. There was no autopsy; but Mr. Kesteven thinks it was not the result of embolism. He attributes it 'to spasm of the glottis from mental emotion.'"*

Here is evidence having direct bearing on the subject:†—At a discussion at the Obstetrical Society as to the danger of the styptic injection, Dr. Bantock related a case of accidental hæmorrhage to which he had summoned Dr. Barnes, "who arrived in due course, and after a short delay extracted a small child with the forceps, dead. The placenta was at once removed, along with a considerable amount of

* Barnes, *Obstetric Operations*, p. 547.

† *Obstet. Trans.*, vol. xv. p. 71.

coagulum, evidently the result of the primary hæmorrhage. There was then no hæmorrhage, and the uterus was well contracted; but, taking into account the exhausted state of the patient, and the probability that any amount of post-partum hæmorrhage would prove fatal, he thought it advisable to inject the uterus with a solution of perchloride of iron as a measure of precaution. No sooner was the iron injected than the patient began to complain of severe pain in the hypogastrium." She died seven or eight hours afterwards.

It is most important to recollect that during pregnancy the coagulative property of the blood is great, on account of an increase in its fibrin-forming constituents. A plethoric state also obtains in pregnancy, so that a considerable loss of blood may occur during parturition, without such loss being gravely felt. There is, too, always a natural tendency for hæmorrhage to cease, since the percentage of fibrin rapidly increases during bleeding. Owing to these fortunate circumstances, therefore, coagula of strength sufficient to resist further loss of blood are usually formed; and it is scarcely necessary to add that safety is secured by a permanent contraction of the uterus. These facts are not adduced to encourage a negligent management of the third stage of labour, but to illustrate the fallacy of undue resort to very active treatment.

If, however, after delivery, the uterus relax, and profuse hæmorrhage occur, persisting after a fair

trial, and in spite of the usual hæmostatic measures—though the cases where the bleeding cannot be controlled by the use of ice are few indeed—then perchloride of iron should certainly be employed. It seems far safer to make the application to the placental site by means of a swab than to inject the solution.

Further, "Dr. Cory* showed the uterus and appendages of a woman (*æt.* 40) who died in St. Thomas's Hospital. She had been admitted on account of uterine hæmorrhage, for which she had suffered for ten weeks since the expulsion of a vesicular mole. A fortnight after admission she had such a severe attack of bleeding that the resident accoucheur injected, by means of a Higginson's syringe, a solution of perchloride of iron through a long tube, which entered the uterus through a considerably dilated cervix. The woman became suddenly collapsed, and died almost before the tube could be removed. At the post-mortem examination a small quantity of darkish fluid was found in the recto-vesical pouch; this contained a large amount of iron. A portion of vesicular mole still remained attached to the uterine wall. The fluid appeared to have entered the peritoneal cavity through the left Fallopian tube."

With regard to the hæmorrhages which often happen during the puerperium—caused by the retention *in utero* of a small piece of placenta—the bleeding can generally be most readily checked by removing the

* *British Medical Journal*, 1879, vol. i. p. 630.

so-called polypus with the finger or curette, the cervix uteri having been previously dilated, if necessary, artificially. If the bleeding do not cease on the ablation of the placental polypus, the uterine cavity can be packed with ice, or "swabbed" with a solution of iodized phenol—a method of treatment which, in my hands, has proved most successful, and is free from danger.

But transfusion is not often called for to combat the anæmia consequent on hæmorrhages of this character, for, being intermittent, they do not generally produce the sudden and powerful effect on the system as do the copious gushes of a *post-partum* hæmorrhage; for in the former case the vessels have time to adapt themselves to the diminishing quantity of fluid they contain, whilst in the latter they have not.

In 1848, at the St. Giles's Workhouse, Sir Spencer Wells, then Mr. Wells, injected saline solutions into the veins of some cholera patients there, with Mr. Bennett, who was at that time resident surgeon. Sir Spencer Wells has informed me that in one case the injection was performed with considerable difficulty, upon a man apparently dead, some few minutes after the heart had ceased to beat; but it was followed by a return of pulsation, warmth and consciousness, and the patient lived for a few hours afterwards.

Though in Roussel's tentative transfusions of blood (performed shortly after death), the results were negative, yet here we have positive and irrefragable evidence as to the value of the operation (on dynamic

grounds) for prolonging life under certain circumstances, when all other therapeutic means would probably be quite useless—evidence which most strongly supports the proposition that, provided with a suitable and ready method, no practitioner should neglect the intravenous injection of fluid in those not hopeless cases of collapse from cholera, or from the effects of severe hæmorrhage, where life is apparently only just extinct.

There are a few rare instances where transfusion should be performed for acute anæmia, caused by bleeding occurring in persons of the hæmorrhagic diathesis. It is true that, as a rule, transfusion is contra-indicated in hæmophilia, lest a fatal hæmorrhage should occur from the seat of the operation, and there are records which show that this objection is, to some extent, a valid one. On the other hand, a case may be cited* where marked success followed the transfusion of about five and a half ounces of blood and water, after the ultimate arrest of hæmorrhage from a strabismus operation, by Dieffenbach's method. Hæmorrhage did not take place from the wound necessarily made to effect transfusion, and it is stated in Ziemssen's "Cyclopædia of Medicine" that the hæmorrhage from venesection wounds, in bleeder people, is not usually serious.

Referring to the pathogenesis of the disorder, it appears that, should transfusion be performed when death seems imminent from acute anæmia—and it

* Lane, *Lancet*, 1840, p. 186.

would only be under such circumstances that the operation would be admissible in hæmophilia—the hæmorrhage having been arrested, the intravenous injection of fluid rather than of blood should be elected, the former being the less stimulating, and only a small quantity of fluid should be injected.

In some cases of enteric fever, of phthisis, of scurvy, of idiopathic anæmia—in short, in many varieties of chronic anæmia—transfusion is indicated. In some instances (never in enteric fever) the injection of blood or fluid into the peritoneal cavity, as advised by Bizzozero and others, might be adopted. Absorption from the serous surface would progress equably, though slowly, and the corpuscular richness has been observed, where this method of transfusion (of blood) has been performed, day by day to increase.*

Let it, however, be distinctly understood that transfusion into a serous cavity would be inadmissible in any case of anæmia of an *acute* character, where the speedy absorption of the roborant fluid would be desirable; or in a case of poisoning, for a like reason.

Vivisection has taught us that if fluid be injected into the peritoneal cavity, even under Listerian precautions, in quantity too large for rapid absorption, septic peritonitis ensues. This fact must not be forgotten whilst considering the question of intra-peritoneal injection, and, as having direct bearing on the

* The accuracy of Bizzozero's observations is questionable.

point at issue, may be mentioned the great importance attached (as the result of a vast experience) by Sir Spencer Wells to the careful "toilette of the peritoneum" after ovariotomy. It cannot be disputed, however, that fluids which diffuse readily may be injected into the peritoneal cavity in quantity with impunity.

Lastly, saline intravenous injections are indicated for diabetic coma, on the supposition that the blood is dehydrated in that condition. Benefit has followed, though not always, the operation when thus performed; and it is favourably regarded by Dr. Stephen Mackenzie,* whose laborious investigations on diabetes entitle his opinion to the greatest consideration.

* *Cf.* Mackenzie, *Brit. Med. Journal*, 1883, vol. i. p. 656.

CHAPTER IV.

ITS MODES OF APPLICATION.

GIVEN a case in which transfusion is imperatively and *urgently* demanded—one which will brook no delay (and that such an one *will* present itself, at some time or other, when least expected, to the unwary practitioner is beyond all doubt)—how shall the surgeon operate?

If immediate blood-transfusion, notably after Roussel's or Aveling's methods, be decided on, the following favourable conditions must be present for its due performance:

First, skilled assistance. I do not wish to assert that an able operator has not performed, or that able operators will not perform the operation single-handed, but I maintain there are very few who would care to undertake, and who would not most properly abstain from a serious procedure, which requires much nicety of manipulation.

It is unnecessary to call attention to the trouble often experienced in finding and opening a vein of the recipient and inserting a cannula therein (for owing to

the acute anæmia existing, the vessels are shrunken and collapsed), or that the anxiety of the operator in the case of the double operation must very largely be augmented. This accomplished, "let the giver go to the bedside and place his arm alongside that of the patient," writes an eminent authority.*

Doubtless this procedure has been and will be successfully adopted; in fact, a case is recorded† in which the blood-giver seemed to enjoy the operation, and offered useful suggestions as to its performance. But this is unusual It is notorious that the donor is most prone to faint. And should he be a heavy man, and the accoucheur not very powerful, the practitioner will vote the operation a delusion and his Art a fraud.

Secondly, a blood-giver, who cannot always be obtained at a moment's notice. There are many who regard venesection and transfusion as operations dangerous *per se*—physicians who will refer to cases in which accidents have happened, cases which have proved fatal, the mortality being directly attributable to the operation. Though undue importance should not be attached to these objections, nevertheless they apply with more than double force to direct transfusion, for there the risk involves not only the recipient, but also the giver, and that a healthy life.

Thirdly, the operator must feel confident that his apparatus is in working order, and must possess a

* Shäfer, *Obstet. Trans.*, 1879, vol. xxi. p. 335.

† Aveling, *Obstet. Trans.*, 1873, vol. xiv. p. 102.

reasonable hope that the method adopted will securely provide against the admission of air to the vein operated on and fibrination of the blood *in transitu.*

To take a partisan-like view of the question as to the best method for transfusion would defeat my object. There is undoubted evidence to show that the admission of air to the venous system during operations has not invariably proved mortal, nor has the accident always been followed with alarming symptoms. Fibrination of blood in the transfusion apparatus, too, may occur, yet the coagulum, by possibly choking the tubing, may not pass onwards into the vein of the recipient.

There is, however, grave reason to suspect that one or other of these accidents has often occurred, and has not been unattended with the most disastrous consequences.

I can but refer to the careful records made by eminent, highly competent, and trustworthy observers, and leave the impartial reader to form for himself a judgment on the facts provided for him :

"The apparatus employed was the funnel and syringe of Dr. Blundell. The coagulation of blood was the greatest trouble which interfered with the performance of the operation. The instrument had to be washed out three times, owing to the coagulation during the check of the supply from faintness of the husband, but I believe no clot was injected into the vein. . . . . About five ounces altogether were injected at three separate times into the median

cephalic vein, with the assistance of my clerks, Dr. Cook and Mr. Soper. . . . . She died two hours after delivery." *

Again, "After a few drachms had been transmitted Dr. Meadows . . . . . thought he felt the skin rising near the incision, and suggested that the tube was not in the vein, but in the cellular tissue beside it. This proved to be true, and the tube had to be taken out and inserted into the vein. Its collapsed condition and the want of light made this no easy task; but it was at length effected."—"This accident," adds a footnote, "has occurred several times. In the *Lancet*, Feb. 26th, 1851, a case is related in which it proved fatal." †

Dr. Aveling's instrument is described as possessing cannulæ, the one rounded-pointed for the emittent vein, the other bevelled-pointed for the recipient vein, which when inserted are to be maintained *in situ* by assistants. ‡ Once more, is skilled assistance always obtainable when required? And if the cannulæ be held in the veins by competent assistants, may not those assistants perchance allow them to slip out?

The chief advantage claimed for Roussel's instrument is that the emittent vein is opened with a lancet, contained within a kind of cupping glass, so that a cannula need not be inserted into the giver's vein.

* *Guy's Hospital Reports*, 1869, vol. xiv. 3rd series, pp. 7, 9.
† Aveling, *Obstet. Journ. Gt. Brit.*, 1873, p. 304.
‡ Idem, *Trans. Obstet. Soc.*, 1864, vi. p. 132, *et seq.*

This method bears, however, a prime objection, for there can be no certainty that the lancet will not perforate the posterior wall of the vein, and injure subjacent structures.

With its many stopcocks, its india-rubber bags, and other complex contrivances, all tending to cause the instrument to become readily disordered from disuse, it is hardly ever likely to find favour. It is not now to be found in the extensive armamentarium of the London Hospital, and very few of the instrument-makers in the capital keep it in stock.

Who can answer the searching question, If immediate transfusion by the methods commonly advocated be a *practical* operation, why is it so rarely performed, when the indications for it, though not of very common occurrence, are by no means rare?

It can scarcely be wondered that the lower animals should have been selected as blood-givers, from the very earliest time, in place of man. The arguments which have been urged in favour of using alien blood are these, that no risk to a healthy human life is incurred; that an animal suitable for the purpose can be readily procured; that blood can be obtained in large quantity, and, provided it be drawn from an animal whose corpuscles are not larger than those of man, the employment of the alien blood will be unattended with any special danger.

Only the first of these arguments can be conceded to. As a matter of fact, it is generally easier to procure a man for a blood-donor than a lower animal.

If transfusion be needed for a farmer's wife in the middle of the night, it is easier to transfuse from the farmer himself than to abstract a lamb from the sheep-fold.

If the operation be needed in a large city, do sheep, dogs, pigs, or men most of all abound?

That, so far as our knowledge goes, the transfusion of alien blood is dangerous in small quantities, and always fatal in large, the following paragraphs will prove:

Dr. Aveling, in the *Obstetrical Journal*,* narrates a case of "transfusion of lamb's blood" (nine ounces). "The patient died within one hour; but several successful Continental cases are recorded."

But the Continental cases have not been so very successful:

Hasse's earliest communications † were enough to show that direct transfusion of moderate quantities of arterial blood from the carotid of a lamb into the veins of the human subject might exert a decidedly beneficial influence upon the constitutional symptoms in various forms of anæmia and marasmus. The roborant effects of this operation were repeatedly manifested not only in cases of acute anæmia, but also in the chronic anæmia of phthisis and other exhausting diseases. Hasse did not scruple to recommend his method as being both effectual and free from danger. Nevertheless, his own statements

* *Obstet. Journ. Gt. Brit.*, 1874, p. 223.
† *Cf.* Ziemssen, *op. cit.*, p. 482.

have made us acquainted with a series of pathological changes and peculiar symptoms more or less invariably consequent upon the transfusion of blood from an animal of another species, and quite unknown after the transfusion of defibrinated human blood.

It is not till after the patient has run the gauntlet of these dangers that he begins to feel the benefit of the operation. A feeling of imminent suffocation and actual syncope was frequently observed when the blood was allowed to flow into the veins too rapidly and for too long a time; but these are symptoms which have been noticed after the incautious introduction of large quantities of human blood. The symptoms I am now about to mention are, however, of a peculiar kind. Rigors, severe though brief, attended by a great rise of temperature, have been observed both by Hasse himself and by all his imitators. These rigors almost always occur during the twenty-four hours immediately succeeding the operation. Again, peculiar disturbances are not unfrequently developed in the kidneys, partial suppression of urine and hæmaturia being their most important symptoms from a clinical point of view (O. Hasse, Sander, Thurn, Klingelhoefer, Brugelmann, and others). Concerning some other less usual phenomena (extensive thrombosis in the vein employed for transfusion, phlebitis, etc.), I will say nothing; for, although their occurrence may possibly be connected with the transfusion of dissimilar blood, that connec-

tion is not susceptible of being proved. I will also pass over the risk of coagulation of the blood *in transitu*, a risk not wholly obviated by the procedure of Hasse and Gesselius ; for it is due to the blood not having been previously defibrinated, and it is obviously independent of its having been derived from an animal of another species.

The cause of the peculiar and violent febrile paroxysms (Hasse has himself seen the temperature rise to 107·6 deg. Fahr.) is still obscure, but the phenomena, though usually of short duration, ought to make us hesitate before we recommend the transfusion of lamb's blood for general adoption. The hæmaturia and associated disturbance of the renal function have, however, been fully elucidated by the laborious researches of Ponfick.

Ponfick ascertained that in dogs, rabbits, etc., neither hæmaturia, nor other grave symptoms, was produced by the careful injection of small or considerable quantities of blood, defibrinated or not defibrinated, taken from an animal of the *same species*, while relatively small quantities of blood from an animal of a different species always sufficed to ensure severe hæmaturia. When the quantity of dissimilar blood transfused was considerable, the operation was followed—no matter whether the blood had been deprived of its fibrin or not—by almost absolute anuria, speedily terminating in coma and death (within from thirty-six to forty-eight hours).

Peculiar alterations in the kidney are invariably

found in animals who succumb to the operation, and in those less seriously affected who are killed for the purposes of examination. Both kidneys are always greatly swollen; large portions of the straight and convoluted tubuli are found blocked up by granular and blood-stained casts, a variable number of which may be detected in the scanty and sanguinolent urine. These appearances are sufficient to account for death; and, taken together with the symptoms presented during life, they entitle us to conclude, with a high degree of probability, that any considerable quantity of alien blood introduced into the circulation sets up an acute nephritis which tends, when at all severe, to a rapidly fatal issue, with uræmic symptoms and suppression of urine.

Nor did Ponfick's experiments stop here. This careful observer also showed that both immediate and mediate transfusion, when properly performed on animals of the *same species*, was quite harmless, yet if the blood were frozen and thawed before defibrination (by which process it was rendered "laky") hæmoglobinuria and the concomitant train of symptoms followed the introduction of this blood into the venous system. Ponfick also transfused from the fowl to the dog, afterwards examining the two kinds of blood thus mixed, and demonstrating microscopically that the alien were so acted on by autochthonous corpuscles that the hæmoglobin of the former was discharged into the plasma.

This series of experiments, coupled with the results

of the heterogeneous transfusions of Hasse and others, prove that plasma containing hæmoglobin exerts a peculiarly phlogogenous influence on the kidney, and that, therefore, the introduction into the venous system of alien corpuscles is not by any means the *only* method of transfusion to be dreaded, for any method whereby the hæmoglobin would be discharged from its corpuscular nidus must be denounced as unsound practice. In these experiments, too, we find an explanation why some physicians inveigh against the transfusion of *large* quantities of (human) blood. Are there not good grounds for suspecting that in indirect transfusion, the blood may become "laky" during the process of defibrination, and though the intravenous injection of a *small* quantity of this fluid might, though not innocuous, be at least not deadly, a *large* quantity might prove a lethal dose?

Dr. Braxton Hicks* has shown that by the addition of a *certain quantity of a solution*† *of phosphate of soda* to freshly-drawn blood will prevent fibrination. For ease of application Dr. Hicks's method is excellent. The donor can be readily depleted, and the solution of the phosphate added to the blood procured in a room apart from that in which the patient is lying; therefore the superiority of this method over immediate transfusion, on grounds of convenience, is obvious.

But evidence is lacking to show that it is sound

* Hicks, *Guy's Hospital Report*, 1869, 3rd series, vol. xiv. p. 7, *et seq.*

† Water, whose sp. gr. is elevated to 2·5 by the addition of phosphate of soda.

practice to introduce abruptly into the vascular system phosphate of soda in proportion far exceeding that which normally exists in the blood, and a record of four successive fatal cases, by Dr. Braxton Hicks, treated by his "new plan" must certainly tend to shake one's confidence in it. It is, however, only fair to add the two cases recorded in the same communication*—cases treated by the "old plan"—were fatal also.†

In 1839 James Blake‡ performed an elaborate series of experiments which demonstrated that, on those lower animals he subjected to the procedure, the intravenous injection of small quantities of *strong* solutions of the salts of potash and soda, particularly the nitrate of potash, rapidly proved fatal. Is the *phosphate* exceptional to the other salts of soda in its effects when introduced into the venous system?

Let the unprejudiced reader place one or two drops of Dr. Hicks's solution (at 100° Fahr.) on the surface of a well-cleansed finger. By pricking the finger with a needle through the globule a little blood will immediately rise into the solution, and the mingled fluid can at once be examined microscopically on a hot stage.

* Hicks, *loc. cit.*

† Judging from the careful record of the *second* of these two cases which I have quoted at length in the preceding chapter (p. 22), there is reason to believe that the rapid extraction of the child was *the cause* of the post-partum hæmorrhage to which the patient succumbed; that the transfusion (by the "old plan") was perfectly successful, and indeed highly beneficial, *in no way causing the fatal result.*

‡ *Archives Gen. de Médicine*, 1839, 3rd series, tom. vi. p. 289.

The red corpuscles will be seen very rapidly to lose their biconcave outline, to increase in size, and become translucent.

If such changes take place under the eye of an observer, they will also occur with equal certainty in a Hicks's syringe.

What special changes precisely occur in the vascular system when a preparation of blood and phosphate of soda solution is introduced therein might most probably be elucidated by vivisection. Was not the great value of transfusion as a therapeutic method proved in 1665 in England by vivisection? Have not Ponfick's vivisections in a foreign country added most materially to our knowledge on this subject? And yet we are deterred from, or, at all events, seriously hindered in pursuing an investigation for the future benefit of our race by the arbitrary trammel of a restrictive and oppressive legislation, which, whilst sternly denying to us the right of experimenting on lower animals, in no way prohibits, and probably never contemplated the performance of experiments on men!

However, with the knowledge afforded by the microscope, and considering the unstable relation of hæmoglobin to the corpuscular stroma, as well as the free solubility of the former in Dr. Hicks's solution—with the experience derived from Ponfick's researches as to the highly phlogogenous action which hæmoglobin in plasma possesses on the kidney—and, above all, with Dr. Hicks's series of cases before us, we are

not justified in adopting this method of transfusion, when there are others equally efficacious, more applicable, and free from special danger.

Indirect differs from immediate transfusion in this, that the donor being depleted by the ordinary operation of venesection, and the blood drawn tending rapidly to coagulate, fibrination is accelerated by means of whipping, so that the fluid subsequently injected into the vascular system of the recipient is not whole blood, but blood minus its coagulum.

The material advantages of the indirect over the immediate operation lie in the facts that the donor, often a near relative of the patient, need not be brought to the bedside of the recipient, that the risk to the donor is lessened, and the entire procedure being divided into two distinct stages, the method is more manageable, and the operator requires much less assistance.

On the other hand, the blood drawn is exposed to the atmosphere—an atmosphere laden with germs—and is not transfused in its entirety, so that its value is diminished, and much of its quantity wasted. The borderland between the classes is occupied by Dr. Hicks's method, for though indirect in point of application, it simulates the direct method very closely, whole instead of defibrinated blood being transfused, as in the mediate operation.

The fallacies which beset this method have been pointed out in the preceding pages.

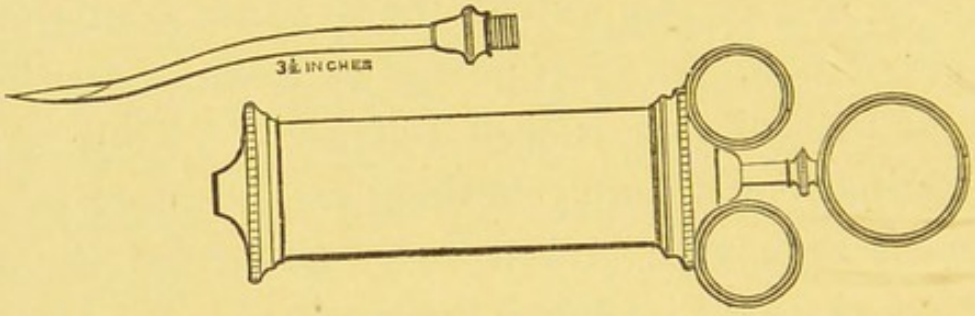
Schäfer's observations* on lower animals show that it is quite safe to inject into the vascular system a fair quantity of freshly-drawn milk, or of milk boiled after standing, but that it would be fatal to inject ordinary milk not so boiled, and that London milk is especially deleterious.

"An argument in favour of saline fluids" for intravenous injection "lies in the fact that the drained circulatory system labours not alone under the loss of the vivifying element, but also under the purely mechanical difficulty of vacuity. The heart and arteries have nothing to contract upon. Now the simple injection of ten or twelve ounces of fluid restores, to a certain extent, the dynamic condition of the circulation. And it is proved by Little's experience that saline solution is well tolerated." Thus writes Dr. Barnes,† and surely nothing can be more logical than his argument, and if to it be added the fact that, in cases of profound hæmorrhage, the process of absorption and assimilation is arrested, so that to administer stimulants and oxytoxics at such a period is simply childish; but if by means of blood-transfusion, or saline intravenous injection, the equilibrium of the circulatory system and of the all-important function of absorption be restored, the key to the rational treatment of severe hæmorrhage is found.

The woodcut illustrates the transfusion-syringe employed at the London Hospital, an instrument

* *Obstet. Trans.*, 1879, vol. xxi. p. 338, *et seq.*
† Barnes, *Obstetric Operations*, 1876, p. 579.

which, though efficient in the hands of an expert surgeon with able assistants, would prove unmanageable and dangerous under other circumstances. These are the disadvantages an instrument of this kind possesses: First, being made of brass, it is an extremely good conductor, and a deal of heat must therefore necessarily be lost from the fluid about to be injected; secondly, being of this metal, it is also non-transparent, nor does a glass interruption exist anywhere, in the syringe illustrated, for the purpose of affording observation; thirdly, the cannula is attached to the cylinder by means of a screw instead of "plugging-on;" fourthly, owing to



its small capacity (a capacity of less than three ounces), the component parts of the syringe have to be unscrewed and readapted many times, for the purpose of refilling it in order to inject a fair quantity of fluid. In the case I have quoted, sixteen ounces of fluid were injected before the good result was obtained; and the operation was at once desisted from, for though wishing to inject a larger quantity, with the view of increasing the dynamic effect, I was mindful that the risk of admitting air to the venous system, whilst replenishing the syringe, was extremely great.

Two other objections to this instrument may be mentioned. It must be filled *by an assistant*, for the fingers of one of the operator's hands being engaged in maintaining the cannula *in situ* within the vein, and preventing the access of air to it, it is impossible for him to charge the syringe with his other hand. Further, during the process of transfusion, the fluid in the receptacle is speedily cooling, so that whilst at the commencement of the operation, in the case cited, the thermometer in the basin of fluid stood at 100° F., towards the close of the procedure it had fallen many degrees.

Since the liability of a cannula to slip out of a vein into which it has been inserted is very great, it must be acknowledged that every transfusion cannula should be provided with a suitable groove for a ligature, which should invariably be applied. It may be mentioned in this connection that given a vein opened, a cannula inserted therein, and transfusion commenced, if proper precautions be not adopted, blood will emerge from the wound in the vein immediately on the distal side of the cannula, and if not prevented, will also flow from the opened vein before the insertion into it of the cannula, to the annoyance of the operator. I very strongly support the advice annunciated many years ago in primitive English that the operation should be performed "by making ligatures on the veines, and then opening them on the side of the ligature towards the heart."*

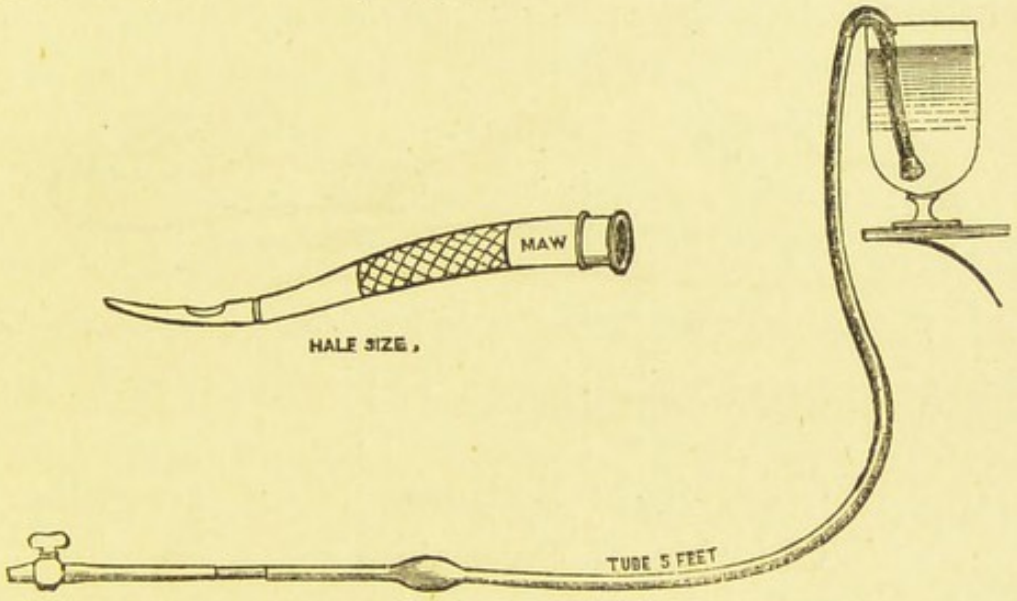
* Aveling, *Obstet. Journ. Gt. Brit.*, 1873, p. 289.

Since transfusion must be performed, though always deliberately, generally with rapidity, a cannula having the following characteristics will greatly aid the operator: an extremity which tapers to a point—a point, however, not sufficiently sharp to perforate the wall of the vein whilst lying therein; a part engraved or embossed, where held by the fingers, to afford a secure grasp; a serpentine form, which will not only favour ease of introduction, but being so shaped, the instrument when introduced within the vein will not displace it from its surroundings by dragging on the integument, as will one of any other form, unless maintained *in situ* by the hand. Last, but not least, the aperture for the egress of the blood or saline fluid should be some little distance from the point of the cannula, that it may be closed by the pulp of the operator's index finger while the point is being inserted into the opened vein.

To open the vein by cutting a flap in it with a scissors, instead of by means of a puncture with the scalpel, is a needless complication, having the disadvantage of wasting time, which the use of an additional instrument involves. What surgeon, performing tracheotomy, would elect to open the trachea with a scissors?

The engraving illustrates a syphon I have devised for intra-venous injection. A piece of rubber tubing, five feet in length, provided with a small bulb for exhausting the air contained in it, prior to use, and a glass interruption in its continuity for the purposes of observation, constitutes this instrument, which very

closely imitates the common nasal douche. Where the tubing passes over the edge of the vessel containing the fluid for injection, it is protected from pressure by means of a semi-circular canal of vulcanite through which it passes. The extremity for the ingress of the fluid is guarded by a metallic grating, that for its egress by a stopcock, to which a cannula, of size suitable for the vein selected for operation, can be "plugged-on."*

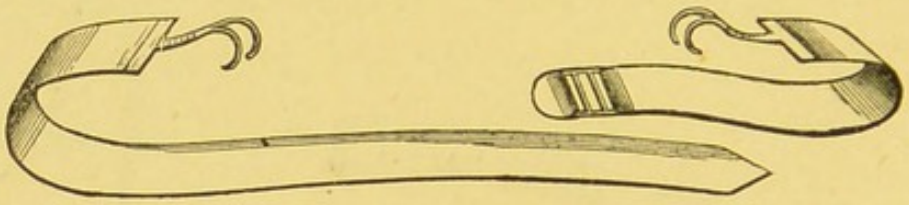


It has been objected that the fluid, in passing through five feet of tubing, will lose much heat. From experiments with regard to this point, it appears that owing to the fact of india-rubber being a bad conductor, only a fractional part of a degree of heat is thus lost. The temperature of the fluid can be estimated, sufficiently well for practical purposes, by inserting a thermometer in the receptacle; or with unerring exactitude by means of a thermometer con-

* A burette-clip may be advantageously substituted for the stopcock.

structed within the glass tube (near the cannula), and such an one has been made for me at Berlin.

A small case contains this syphon (made by Messrs. Maw, Son & Thompson), some cannulæ of different sizes, a pair of dissecting forceps, with five points, a scalpel, aneurism-needle and ligatures, a graduated bottle for alcohol ; there is also room for some saline powders, and for an automatic retractor, which will be found most useful in the performance of the operation.



Each powder contains—

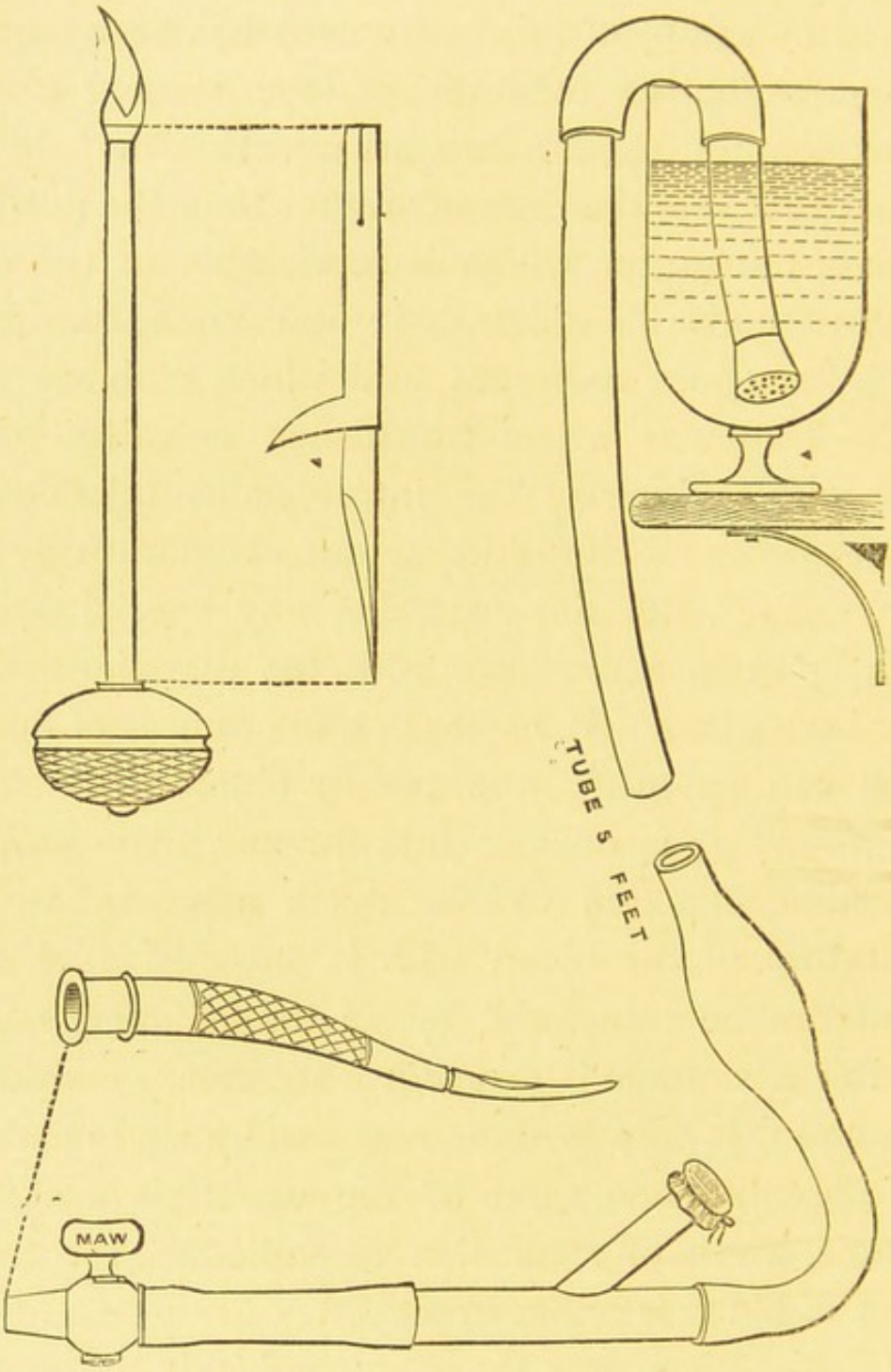
Chloride of Sodium	50 grains
Chloride of Potassium	3 „
Sulphate of Soda	2·5 „
Carbonate of Soda	2·5 „
Phosphate of Soda ($Na_3 PO_4$)	2 „

If one of these powders be dissolved in twenty ounces of water at 100° Fahr., and two drachms of absolute alcohol be added, a solution, similar to that employed by me in the successful case I have quoted, is at once produced. The syphon can be charged almost instantaneously, the air in it being expelled by compressing the bulb, the method being too obvious to require any explanation.

Since this syphon has been adopted at the London Hospital, it has there been successfully employed, and the great ease with which the operation may be performed by means of this instrument has been demonstrated. The explanation of the success usually consequent on the intravenous injection of fluid lies in this, that it is the *dynamic* rather than the nutritive value of transfusion which is serviceable in the class of cases under consideration; and, under conditions which have been indicated, and which embrace *most* of the instances where transfusion is called for, I unhesitatingly advise the intra-venous injection of fluid as being certain in its action, comparatively free from danger, and not requiring any special skill if carried out in accordance with the directions which have been given. If, however, a few ounces of human blood can be safely and readily obtained (*which is exceptional*), it is obvious that the nutritive *quality* of the saline injection will be much enhanced by the admixture of the blood with it, most of all if that blood can be transfused by an immediate method; but this advantage is *generally* a secondary consideration, and it is only in some *rare* cases, such as carbolic acid poisoning and some of the varieties of chronic anæmia, where, if tranfusion be indicated, the transfusion of blood is indispensable.

If in any given case the operator decide to transfuse blood and possess that skilled assistance without which very few would be disposed to perform immediate transfusion at all, let him substitute for the

glass interruption in the tubing of the syphon a Y-shaped glass tube, having the additional aperture



capped over with a piece of indiarubber after the fashion of the stopper of an atropine-solution bottle. The steps of the operation are: first, to charge the

syphon with the saline fluid and to insert the cannula into the recipient's vein; secondly, the blood-giver being placed in a suitable position, and his arm being bound as for venesection, to tap a vein with a trocar and cannula (of special design);* thirdly, to plunge the free extremity of the cannula (which is penshaped for the purpose), hanging out of the donor's vein, through the rubber cap of the Y- tube of the syphon. Immediately the giver's blood will mingle with far more than its bulk of saline fluid in the glass tube; and we know that such an admixture (especially if the saline fluid be first slightly ammoniated and of a temperature of about 75° F.) most materially retards the coagulation of blood.

The tension being considerably greater in the giver's vein than in the receiver's, the blood of the former now mingled with saline fluid, must flow into the vein of the latter, *i.e.* towards the *locus minimæ resistentiæ*, the process being regulated by the syphon. The oval rubber bulb in the instrument is not for the purpose of propelling either the fluid or blood (as in the case of Dr. Aveling's transfusor), but for one of cleanliness and convenience—to obviate the necessity of charging the syphon by suction with the mouth.

An important feature in the value of this combined

* The integument over the vein having been first incised with the scalpel. This preliminary is necessary, owing to the different degree of resistance which would be otherwise offered to the trocar by the skin and wall of the vein respectively.

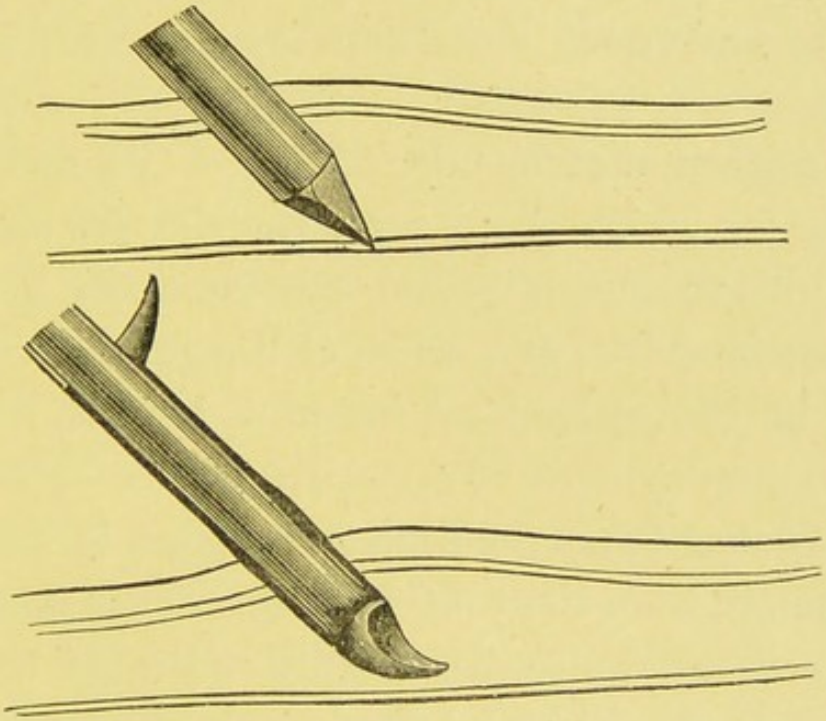
method is, that when the donor faints from loss of blood, that loss can instantly be supplemented by a few ounces of saline fluid ; for, by turning off the stopcock of the afferent cannula, the saline fluid will immediately flow in the reverse direction into the donor's veins.* This substitution of saline fluid for blood may not at first sight appear so valuable as it really is, but the vascular system will be repleted thereby, and this is the chief argument on which transfusion for hæmorrhage is based.

The trocar and cannula I have devised for phlebocentesis possess these details : The cannula is two and a quarter inches in length, having its shield equidistant from its extremities. This shield is only semi-circular, for were it completely circular, it would, by pressing on the integument, prevent the cannula from lying evenly within the vein.

The annexed engraving shows that the head of the trocar should be somewhat turned up, that its tip may not penetrate the posterior wall of the vein operated on (as would that of an ordinary trocar). To open the afferent vein with a trocar and cannula, would, owing to the flaccid condition of the vessel from the existing anæmia (for which the operation is usually resorted to), be impracticable; not so in the case of the donor, the veins of whose forearm

* It has been objected that the flow of the fluid would be arrested by the valves in the donor's veins. But this objection would only hold good if a valve existed between the cannula and the nearest collateral venous branch.

have been rendered turgid by the application of a turn of a bandage. Again, to lay open and to insert a cannula into the receiver's vein, though tedious, is painless, owing to the general anæsthesia present, consequent on the hæmorrhage; but this remark would not apply to the giver, in whom no such anæsthesia would exist, and the process would be exquisitely painful to him. Hence the object of the trocar and



cannula, since by its means blood may be drawn almost at a single plunge.

Sir Spencer Wells directed to be made for him many years ago a trocar and cannula for transfusion purposes; the head of the trocar fitted the rim of the cannula so accurately (the former slightly overlapping the latter), that the united instrument would easily glide into a vein. The head of the trocar tapers gradually from base to tip, is a little curved (which

is sufficient for its object), and a section taken near the point would be triangular.

I am exceedingly indebted to Sir Spencer Wells for his kindness in furnishing me with a drawing and description of this trocar, and for his courtesy in permitting me to illustrate (*vide* p. 58) his instrument in this treatise.

The addition of a trocar, cannula, and glass tube to the original apparatus does not materially increase its bulk, and does not therefore diminish its portability.

The operation of blood-transfusion is a serious one, and one for which fortunately the simpler method of saline intravenous injection can generally be substituted successfully ; but its chief danger (that of fibrination in the apparatus) would, I believe, disappear with the employment of my instrument.* Nor should it be forgotten that the blood of males is less prone to coagulate than than of females. This fact, added to other considerations, certainly indicates that, as a rule, a male should be selected as the donor whenever blood-transfusion is demanded.

* Before using this instrument, the reader is strongly advised to consult (if he have not already done so), Dr. B. W. Richardson's "Essay on the Cause of Coagulation of the Blood."

SUMMARY.

En resumé, the main points of interest the subject presents, might be condensed into the propositions:—

1. That, within certain limits, saline fluids may be substituted for blood in the human subject with safety.

2. That the intravenous injection of fluid by the syphon may be readily carried out by any practitioner alone; or the transfusion of blood with the aid of skilled assistants.

3. That the chief objection to blood-transfusion is the danger of fibrination *in transitû;* and it is calculated that this objection cannot apply to the syphon, coagulation being retarded in the following way:*

(*a*) By exclusion of air from the blood, the method being direct.

(*b*) By the rapid admixture of the blood with *more* than an equal bulk of saline fluid, at a temperature of about 75° F.

(*c*) By the flow of the blood being regulated by the fluid in the syphon—at once a *vis à tergo* and a *vis à fronte.*

* This point is capable of determination by vivisection.

(*d*) If necessary, by the addition of ammonia to the fluid, in quantity not exceeding ·5 per thousand.

4. That saline intravenous injection or blood-transfusion is strongly indicated in *all* cases where life is threatened by hæmorrhage, or the collapse consequent on it, the election being determined by circumstances; the simultaneous arrest of such hæmorrhage being regarded as a *sine quâ non.*

5. That saline intravenous injections are most beneficial in cholera, and that if supplemented by transfusion of blood, the results would be probably better, on *nutritive* grounds.

6. That blood excels saline fluids for transfusion purposes, in respect of its corpuscles; but the *dynamic* effect of the operation being *generally* required to restore suspended animation in suitable cases, saline fluid will usually be found an efficient substitute for blood.

7. That transfusion of blood from the lower animals is inadmissible.

APPENDIX.

WHILST the MS. for the first edition of this publication was being prepared, the notes of four cases in which the syphon (illustrated on p. 55) had been employed for intra-venous injection were sent to the journals in two distinct communications. The following cases were published in the *Lancet,* Dec. 30th, 1882, by Mr. Coates :

The first case is that of Emily C——, aged twenty-six, a patient of the London Hospital Maternity Charity. She is a married woman, has had five children, but has always been delicate. Has had heart disease for some years, having had rheumatic fever when young. On October 16th she was taken in labour early in the morning, and at 1 p.m. I was summoned to the case. The patient was feeble, pulse rapid and intermittent, and she had stenosis and incompetence of the mitral valve. The head was low in the pelvis, in the second position, but as the pains were few and there had been no further descent during the last three hours, delivery was effected with Barnes' long forceps, and the placenta easily expressed. About twenty minutes after delivery violent hæmorrhage occurred. Manipulation, hypodermic injection of sclerotic acid, cold affusions, ice internally and externally, the intra-uterine injection of hot water, were all resorted to ; but these measures failing to produce more than

temporary uterine contraction, ten ounces of a solution of perchloride of iron (one in five) were injected into the uterus. The hæmorrhage ceased, and after the lapse of a little time the uterus contracted moderately. The patient progressed favourably, and seemed in a fair way towards recovery, when, contrary to instructions, she sat up for an hour on November 1st, and again began to flood. She was found in an anæmic weak state, but the hæmorrhage was easily arrested. Two days afterwards the bleeding returned, and the friends did not summon assistance until she had been "losing" for eight hours. When seen the bed was saturated with blood, and the patient appeared almost moribund. Pulse was only just perceptible at the wrist, and very frequent; skin and mucous membranes were almost bloodless, extremities and nose were icy-cold, vision was dim, she did not recognise any one about her, and was seemingly unconscious. Although now quite still, her friends stated that she had been tossing violently. My colleague, Dr. Basil Walker, agreeing with me as to the necessity for immediate action, and the husband being unwilling to supply blood, Jennings' syphon was procured, and the saline alcoholic solution recommended by him (the *Lancet*, September the 16th), and which is almost identical with that suggested by Mr. Little in the London Hospital Reports (1866), was allowed to flow into the radial vein, this being the only visible one and of fair size. The result was marvellous. Sight and consciousness returned, the pulse gradually but steadily improved, the patient expressed herself as feeling "beautiful," and soon was able to retain stimulants, which were freely administered. She had a good night, seemed better in the morning, though extremely anæmic and weak, and the possibility of another outburst of hæmorrhage being entertained, she was brought into the hospital. With the exception that symptoms of acute mania appeared on November 17th, her progress has

been most favourable, and recovery is probably not very remote. To give some idea of the intensity of the anæmia it may be stated that retinal hæmorrhages have been observed in both fundi.

The next case is that of Mary C——, aged twenty-seven, a patient of the same charity. On November 10th she was confined of a healthy child after an easy labour. Her convalescence apparently proceeded rapidly. She sat up on the fifth day and performed household duties in a week. On the 19th, soon after straining at stool, she became faint, and then flooded alarmingly. At 1 p.m., half an hour after the onset of the hæmorrhage, the appearance of the patient betokened severe loss of blood, which was found in large quantity upon the floor and bed. The uterus was relaxed, and blood was flowing in gushes from the vagina. The os just admitted a finger, and the uterus was full of clots. Sclerotic acid, ice, kneading, etc., failing to arrest the hæmorrhage, the vagina was plugged, and patient brought to the hospital. When seen soon after arrival—2.30 p.m.—she appeared much worse, was vomiting, and complaining of abdominal pain. A large tumour was felt, reaching almost to the ensiform cartilage, which proved to be the uterus distended with blood, the constricted os evidently preventing its free exit. A digital exploration of the uterine cavity was now made, the large uterus and small os rendering this incomplete; but nothing abnormal, except a little roughening of the anterior wall, could be detected. Failing to check the bleeding, and wishing to ascertain its origin, the os was somewhat rapidly dilated with Barnes's hydrostatic bags. By this time, however, the state of the patient had become most critical. She said her sight was dim, and that she must die. The pulse was almost imperceptible; respiration was irregular; extremities cold; and there was jactitation. Mr. Unsworth, house-surgeon, concurring

with me that there was no time to be lost, and no vein being visible, an incision was made over the situation of the median cephalic, and that vein exposed, into which about twenty-two ounces of simply warm water, at a temperature of about 100° F., were injected with the aid of Jennings' syphon. The result was no less striking than in the preceding case. The pulse became regular, ceased to intermit, and its volume increased; respiration improved; sight retained; and the uterus slowly but distinctly contracted; she at the same time expressing herself as feeling better. At about 4.30 p.m. Dr. Herman saw the patient, and, the os being now fairly dilated, the interior of the uterus was examined, but nothing further was discovered to explain the flooding. As there was still considerable bleeding, the uterus was swabbed out with a saturated solution of perchloride of iron, diluted with about equal bulk of water, and the patient was removed to bed. An enema of beef-tea and three ounces of brandy was administered; but in a short time she could swallow, and stimulants were freely exhibited. The patient is now progressing uninterruptedly towards convalescence, not having had a bad symptom, except a slight elevation of temperature (102° F.) the first few days.

The following cases were published in the *Medical Times and Gazette*, March 17th, 1883:

Case 1.—*Placental Polypus—Hæmorrhage—Intravenous Injection of Saline Fluid—Death.*

Susan S——, aged twenty-eight, a patient of the London Hospital Maternity Charity, was confined on November 27th, 1882, of a healthy male child, after an easy labour. The placenta came away without trouble after a little expression. It was her third confinement. She had been in fairly good health whilst pregnant, but had not been able to obtain

much nourishment during the last few weeks. After delivery, her convalescence progressed favourably until December 6th (nine days), when she lost a little blood. The Maternity assistant attending her reported that the hæmorrhage was slight, that the uterus appeared fairly contracted, and that the bleeding ceased after the administration of a little ergot. All went well for three days, and she had been sitting up a little in the afternoon of December 9th, when at 8.30 p.m. an urgent message was received that the patient had been flooding for the last two hours. She was found delirious, extremely anæmic, with cold extremities and marked jactitation. She had lost a great deal of blood, which had soaked through the bed, and was seen in considerable quantity upon the floor. Her pulse was irregular and small, beating 129 in the minute. On examination, there was a little blood oozing from the vagina; the os was patulous, admitting one finger. Bimanually the uterus was felt enlarged, and at the fundus a mass could be felt, irregular in shape, about the size of a bantam's egg, adherent to the uterine wall. The smallest of Dr. Barnes's water-bags was at once introduced into the cervix and distended, by this means checking the hæmorrhage and dilating the cervix at the same time. Brandy, which was with difficulty swallowed, was given freely, and one grain of sclerotic acid injected into the buttock. Dilatation of the cervix was effected with the larger water-bags, and on the arrival of Dr. Herman at 9.30 p.m., the polypus (which proved to be placental) was scraped away with the finger, and the interior of the uterus swabbed out with a solution of perchloride of iron (one in four). Her general condition, however, by this time appeared worse. Her pulse was much weaker. She vomited everything that was given, and tossed herself from side to side in the bed. A vein in the right cubital space was exposed, and one pint of the saline fluid recommended by

Dr. Little ('London Hospital Reports, 1866'), at a temperature of about 100° F., was allowed to flow into it through Jennings' syphon. For a few minutes the patient appeared to revive a little, but this was only temporary, as, five minutes after the injection, she was as bad as ever, and appeared fast sinking. Her extremities and nose became stony-cold, her pupils dilated, the conjunctivæ were only just sensitive, and the respiration slackened and became embarrassed. One drachm of ether was injected subcutaneously over the region of the heart, and this stimulation, aided by artificial respiration, kept the patient alive whilst a blood solution was prepared. About sixteen ounces of blood were procured from the husband, and allowed to flow into a pitcher containing a solution of phosphate of soda at a specific gravity of 1·050, and at about blood-heat. This was filtered and injected into the left median cephalic vein with the aid of Braxton Hicks' apparatus. But she had ceased to breathe before the operation was begun, and died at about 11 p.m.

Case 2.—Accidental Hæmorrhage—Intravenous Injections of Saline Fluid and Blood—Death.

Louisa G——, aged forty-one, also a patient of the Maternity Charity, sent word she was in labour with her thirteenth child, on December 15th, 1882, at 5.30 p.m. It was stated that about an hour previously the patient had been found lying on the bed, swamped in blood, by a neighbour who accidentally called at her house, and as she had not been seen about since morning, it was presumed that she had been bleeding there for some hours. It was gathered from the friends that she had been quite well during her pregnancy until a month ago, when she had fallen down the steps at Broad Street Station. Since then she had complained of occasional abdominal pain, and a week ago fell down her own stairs. There was no history, however, that she had

lost any blood at this time, and, as far as was known, she was at the full term of pregnancy. The patient was found blanched, cold, restless, wishful to be "allowed to die," with a weak, irregular, intermittent pulse, beating 120 to the minute, and occasional vomiting. Abdominal examination showed the uterus as large as at full term, the head presenting, the back anterior. Blood was flowing from the vagina; the os was hardly as big as a shilling, and rigid. The head presentation was confirmed. The membranes were unruptured, and no placenta could be felt. An unsuccessful attempt was made to perform bipolar podalic version, and as the hæmorrhage continued, the membranes were ruptured, one grain of sclerotic acid injected hypodermically, the smallest of Dr. Barnes's hydrostatic bags distended in the cervix, and iced brandy administered by the mouth. Though persevering attempts were made with the water-bags to effect dilatation of the cervix, scarcely any enlargement could be obtained, the os remaining absolutely rigid. At 6.45 p.m. Dr. Herman saw the patient. There had been no hæmorrhage since the rupture of the membranes, and, as turning could not be accomplished, a firm binder was applied, and another grain of sclerotic acid injected. As the jactitation was more marked, the vomiting persistent, the pulse faster and more feeble, and she appeared to be falling into collapse, twenty ounces of Little's saline fluid with four ounces of brandy at about blood-heat were allowed to flow into a large vein in the right forearm, Jennings' syphon being employed as in the case above related. The pulse improved a little during and after the operation, but the patient did not express herself as feeling any better; in fact, the amount of brandy that had been taken, combined with the loss of blood, rendered her quite delirious. As there was no vaginal hæmorrhage, hot-water bottles were placed to the feet, half a drachm of laudanum

was given, and the patient left for two hours. When seen at 10.15 p.m., she appeared worse than before, and was apparently fast sinking. There had been no more hæmorrhage from the vagina; the head was blocking up the os, but this was quite as rigid and no further dilated than when last seen. The husband consenting to give blood, he was bled to twelve ounces, and the blood whipped with a fork as it flowed into a graduated basin. It was then passed through muslin into a similar quantity of saline fluid at a temperature a little over blood-heat. This mixture was again filtered through muslin, and its temperature maintained by placing the containing vessel in a larger one full of hot water. Twenty ounces of the "blood and saline" were now injected into the left median cephalic vein, by means of a ten-ounce brass syringe, about a foot of india-rubber tube, and a suitable glass cannula. The patient appeared to improve a little after the injection; her pulse became stronger, and she recognised those who were around her; but the rally was only temporary, and she gradually sank, and died at 2 a.m. the following morning, eight hours and a half from the time she was first seen.

At the autopsy on the following day, the placenta was found at the fundus almost completely detached, except here and there at its margin. The uterus contained a large quantity of recent blood-clot; but about the placenta there was evidence of old as well as recent hæmorrhage. The os uteri was only the size of a shilling, but it appeared healthy. The child was fully developed.

Remarks (by Dr. Herman).—The attention of the profession has recently been called (by some correspondence in the *Lancet*, and also by a communication to the Obstetrical Society of London) to the intra-venous injection of saline fluid as a means of saving life endangered by hæmorrhage; and cases have been published in which, after this treat-

ment had been used, the patients recovered. It is impossible for the profession to correctly judge of this, or any other mode of treatment, unless *all* the cases in which it is employed are reported; and, therefore, the above cases are published. So far as they go, they favour the view that the effect of intra-venous injections is merely that of temporary stimulation. This, however, if it be admitted, is no argument against their use; for in cases in which, if left to nature, death seems imminent, it is proper to use any treatment which, not in itself injurious, offers a chance of safety.

Throughout this publication, and elsewhere, I have reiterated—and not unnecessarily—the prime importance, in all cases of hæmorrhage, of arresting the flow of blood before resorting to transfusion. Judging from the report of the last case, coupled with the remarks Dr. Herman has appended to it, he apparently does not accept this proposition; and as his statement clearly refers to papers written by myself, I must point out the misapprehension of my views, which has here evidently led to a fatal result. Nor can Dr. Herman show that either myself or other correspondent on Transfusion has said one word which would warrant a woman being permitted to pass into her grave without some more recognised and more determined means being employed to effect delivery than were here adopted.

Surely it has occurred to the minds of all practitioners who have read Dr. Herman's paper that in this case the mother was allowed to perish from *concealed* hæmorrhage (as proved by the autopsy),

augmented by abundant transfusions and heroic stimulation! The chief value of this case lies in its unique character—unique in two respects: First, that with hæmorrhage so profound, the os uteri should have remained rigid to the last; and secondly, that in the year 1882 chloroform, as a means for its relaxation, should have been withheld! Granting that delivery *per vias naturales* was impracticable (of which proof is lacking), why was the patient abandoned for those two hours, and both mother and child deprived of that chance which the Cæsarian operation would have afforded them?

Had chloroform been employed at the outset, dilatation of the cervix, either with Barnes's hydrostatic bags, or with the operator's fingers, would have been easy. That treatment detailed on pp. 26, 27, might now have been employed, and which was there, probably would have been here successful.

The only parallel to the case reported by Dr. Herman would be that of an amputation where transfusion had been performed for hæmorrhage, all the arteries of the stump being left untied.

With regard to the preceding case—that of the placental polypus—whilst, at the risk of being wearisome, I again endorse the aphorism that in post-partum, as in other hæmorrhages, the flow of blood must always be arrested before resorting to transfusion, it has been pointed out that the local employment of iron solutions for that purpose is most dangerous. Here there was no autopsy; and whilst the casual

reader of the record might infer, from the description given, that the transfusions were useless, it is possible, and very probable, that embolism (produced by the perchloride of iron) was the true cause of death.

These reports most forcibly illustrate many points which have been advanced in this monograph, and a careful consideration of them will, I trust, often direct the practitioner to a right prognosis and successful mode of treatment.

Since the publication of the second edition of my work in July, 1883, I have conducted, in this country and abroad, experiments which have absolutely proved the scientific accuracy of the chief propositions which I have advanced, and which, were it not for the evidence thus laid before the Profession, would still have been regarded as *theories* only.

The subject of intravenous injection of milk has also been investigated; but it will appear that this plan of treatment is not of much value, except under certain peculiar conditions. So far as the practicability of transfusion of blood and saline fluid with repletion of the blood-giver's veins with saline fluid is concerned, I have most clearly established the advantages claimed for my method by an instance in which the operation has been performed in actual practice, and which confirms the results of the experiments.

All this has been published during the past four years through the medium of the medical press; and

in the *last* of the following reprinted papers will be found an epitome of the full question :

REPORT OF TWO EXPERIMENTAL TRANSFUSIONS ON DOGS.

PERFORMED IN GUY'S HOSPITAL LABORATORY.

Reprinted from the *Lancet*, Sept. 1st and 14th, 1883.

In previous communications I have endeavoured to draw a marked distinction between the indications for the intravenous injection of saline fluids and for the transfusion of blood, and have suggested that, whenever admissible, the former should be chosen in preference to the latter method, which is necessarily a complex procedure, and if imperfectly performed a dangerous one. Conceiving that the chief objection to direct transfusion lies in the risk of coagulation of the blood *in transitu*, I have published* the description of a syphon apparatus designed to remove this source of danger, by causing the donor's blood to mingle with more than an equal bulk of saline fluid, immediately after quitting the efferent cannula—*i.e.*, on entering the connecting-tube. The chance of coagulation might be further lessened by employing a saline fluid at about 75° F., instead of at blood-heat. The fluid, too, might contain a small percentage of ammonia, as an additional precaution. The vascular system of the donor could be repleted by the substitution of saline fluid for the blood transfused. With the view of determining these points, I have performed, by the courtesy of Dr. Pye-Smith, two transfusions in his laboratory at Guy's Hospital, one of the few places licensed for experiments on animals in the United Kingdom.

Experiment 1.—July 30th.—The operation was performed

* The *Lancet*, March, 1883.

under mixed narcosis, slightly modified from that figured in *The Lancet*,* and charged with an ammoniated saline fluid.† The small size of the animals, the donor weighing 15 lb. 9 oz., and the recipient 12 lb. 4 oz., involving the employment of cannulæ smaller in bore than would be selected for the human subject, coupled with the greater tendency of the blood of the dog to coagulate, as compared with that of man, the anatomical relations of the jugular vein‡ of the dog, and its close proximity both to the heart and to the brain, conspired to render the operation somewhat more difficult than it would be in actual practice. Transfusion was established between the right external jugular veins of the two dogs, the recipient being simultaneously depleted. Saline fluid was then substituted for the blood lost by the giver. The afferent cannula was of No. 1 size, the efferent No. 2.§ After the experiment the recipient was found to have *lost* $2\frac{1}{2}$ oz. (this being the difference between the blood lost by venesection and the mixed fluid gained by transfusion), and the giver to have *gained* $1\frac{1}{2}$ oz. in weight (due to the saline liquid injected). About 10 oz. of saline fluid had been injected into the dogs, and about 3 oz. of blood were collected from depletion of the receiver, besides about half an ounce which was lost. The donor, whose vessels were surcharged, began moving about the more briskly on recovering from the anæsthetic. The recipient, which had been more deeply anæsthetised than the giver, also recovered perfectly, though continuing drowsy from the effects of the morphia for some time. Both dogs were killed the same afternoon.

This experiment conclusively proved that blood would

* *Loc. cit.*

† *Vide* "On Transfusion of Blood and Saline Fluids" (Baillière, Tindall, and Cox).

‡ This being the vein chosen for the experiment.

§ Cannulæ have been made for me of the following sizes, No. 3 having the largest calibre : 3, 2, 1, $\frac{1}{2}$, $\frac{1}{4}$.

mingle rapidly and completely with saline fluid in the junctional tube of the instrument, and, so far as it went, showed —first, that coagulation of the blood did not occur in its passage from giver to receiver; nor were any coagula found within the instrument after the cannulæ had been withdrawn from the veins of the animals; and, secondly, that the saline fluid facilitated the flow of blood, and could be directed into the vein of either dog at will.

The experiment showed, further, that to tap the vein of the donor with a trocar and cannula, as proposed, is impracticable. Unless they be made to fit each other with extreme accuracy, I am convinced that a trocar and cannula would be useless for transfusion purposes. On grounds of convenience I tried the trocar; but having devised a phlebotome (Fig. 1), which greatly facilitates the insertion of cannulæ into veins, I have discarded the former instrument as unnecessary. Therefore a modification of the apparatus in the direction of simplicity has been made. This must be described in detail before narrating the experiment in which it was employed.

The phlebotome is a small instrument, combining the advantages of a knife, hook, and director. Its blade, which is pen shaped, is set at a right angle to the shaft. The upper surface of the blade is slightly convex both from side to side and from before backwards. The anterior third of the lower surface is plane, the middle third slightly concave from side to side, and the posterior third deeply so, in order to afford a suitable guide for the cannula. As in making a corneal section for cataract with a Beer's knife the aqueous humour cannot escape, so in puncturing a vein with this phlebotome, provided only the anterior third of the blade of the instrument be introduced within the vessel, no blood can emerge. Fig. 3* shows an enlarged view of the junc-

Vide p. 81.

tional tube interpolated in the syphon (Fig. 2) at C. The efferent cannula is intended to plug on to the aperature (D). Communication can be established or cut off between the efferent cannula and the junctional tube by partially withdrawing or closing the inner tube (E). A mechanical arrangement exists to prevent the outer and inner tubes from coming entirely apart.* In the preceding experiment a junctional tube of glass, with the communication between it and the efferent cannula not capable of being made or broken at will, was employed. The fact that the blood and saline fluid would satisfactorily mingle having been determined by observation through it, the necessity for a junctional tube of glass, instead of metal, no longer existed.

Experiment 2.—Aug. 8th : The syphon was charged from a receptacle of saline fluid (78° F.), each pint of which contained ten minims of liquor ammoniæ, and the following salts in solution : Chloride of sodium, 50 grs. ; chloride of potassium, 3 grs. ; sulphate of soda, 2·5 grs. ; carbonate of soda, 2·5. The communication between the efferent cannula and junctional tube was shut off. The experiment was performed, like the last, under mixed narcosis. The recipient weighed 20 lb. 1½ oz. ; the donor, 15 lb. 1½ oz. Immediately after the (left) external jugular vein was exposed, its sheath was opened with the scalpel.† The wall of the vein was punctured and slightly elevated with the phlebotome, the afferent cannula (No. 2 size) being quickly introduced beneath it. The cannula was secured *in situ*

* This contrivance is omitted from the diagram, which is of small scale, in order to prevent confusion. The telescopic tube employed in the forthcoming experiment was a brass model, very hastily made for me by Kröhne and Sesemann.

† In order to avoid the chance of introducing the phlebotome between the sheath of the vein and its anterior wall. One other possible error might be committed, which need only be known that it may be avoided —viz., the phlebotome might be thrust through the posterior as well as through the anterior wall of the vessel, and the cannula introduced between its posterior wall and its sheath.

with a ligature. After a lapse of some time it occurred to me that a coagulum might already have formed about the aperture of the afferent cannula from blood within the receiving vein, saline fluid not having been allowed to flow, since the dog was not yet depleted. The removal of the cannula to ascertain this point proved that such was the case. The coagulum having been removed, the cannula was reintroduced within the vein, and the formation of a fresh coagulum provided against by allowing saline fluid to pass *guttatim* at short intervals. Depletion from the vein on the distal side of the cannula was effected, but the flow of blood was tardy. By opening the sliding tube (C), the rubber tubing being closed near the afferent cannula (A) by the burette clip, the saline fluid emerged from the efferent cannula (B). The flow was now arrested by the stopcock, and the efferent cannula (No. 2 size) was inserted into the right external jugular vein of the donor. The cannula being of a conical form, it was first maintained *in situ* by pressure; but blood escaping by the side of the instrument, it was finally secured with a ligature.* On relaxing the pressure made on the tubing by the burette clip the donor's blood rapidly passed through the connecting tube, pressing the saline contained therein onwards. The contents of the glass interruption rapidly became of a deep mulberry colour. Mr. Golding-Bird, who at this moment kindly regulated the stopcock for me, turned on a little fluid. The chief interest in the experiment lay in allowing the saline fluid to mingle with the blood in various proportions, the amount of the dilution of the blood being obvious by the various and rapid changes of colour the fluid in the glass tube (F) could be made to assume. When the first convulsion of the facial

* The absolute necessity of ligating cannulæ within veins was thus demonstrated. In actual practice this step, though painful to the donor, should never be omitted.

TUBE 5 FT
Fig. 1
MAW
Fig. 2
E
C
B
Fig. 3
D
F
A

muscles of the donor occurred,* the flow of blood was arrested by suddenly increasing the pressure of the saline, which now entirely displaced the blood in the instrument. The flow through the afferent cannula was stopped, the saline fluid coursing through the efferent cannula (B), and thus repleting the donor's vessels. The experiment was concluded by removing the instrument and noting that no coagula existed within it. The quantity of saline fluid injected into both dogs was sixteen ounces; only two ounces of blood had been collected from the depletion of the receiver in a vessel, but some had been lost. Some blood was lost from the donor's vein, and also some saline fluid by slight leakage from the junctional tube.† The receiving dog, which had gained five ounces‡ in weight by the experiment, recovered, though it remained drowsy from the effects of the morphia for some time.

In order to test the instrument further, an additional experiment was performed on the donor, still anæsthetised. The efferent cannula of the syphon, charged with saline fluid, was inserted into this dog's left jugular vein, the animal being depleted through the connecting-tube. The blood, on passing the afferent cannula, mixed with saline fluid from the syphon, was received under fluid. A slight convulsion occurring, the dog was repleted with saline fluid; then more blood was drawn and saline substituted for it. The quantity of blood and saline fluid mixed, which was collected in the basin after this experiment, measured nine ounces; the total quantity of saline fluid employed was fourteen ounces. The jugular vein and other bleeding points were ligatured and the wound closed with sutures. A little blood mixed with saline fluid had been left in the connecting tube of the

* This took place quickly, since the blood was flowing directly from the nervous centres.

† The tube employed being a rough model, but tubes similar in outline have since been made free from this fault.

‡ The transfusion being so much in excess of the depletion.

syphon. On being now examined coagulation had begun. The dog was then allowed to recover and run about. It had lost half an ounce in weight by the two experiments. Both animals were soon afterwards killed. It was suggested that possibly the saline fluid infused into the dogs had transuded from their vessels their serous cavities. To ascertain whether this fallacy existed the peritoneal, pleural, and pericardial cavities of the animals were examined post-mortem, but no effusion was found.

For valuable assistance in the first of these experiments

Fig. 4

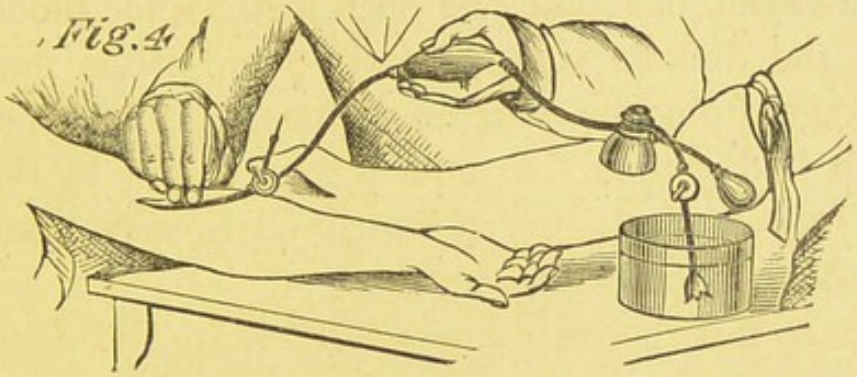
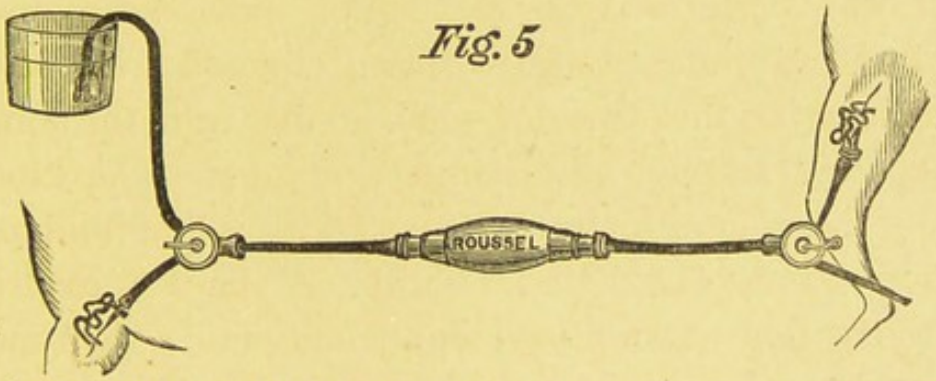


Fig. 5



I am indebted to Dr. Fenton-Jones, and in the second to Dr. Golding-Bird. Nor must I omit to state that the success of the experiments was largely due to the admirable physiological appliances which were placed at my disposal.

Propositions: 1. That by this method there is no danger of coagulation of the blood occurring *in transitu*, if ordinary care be observed in the performance of the operation. 2. That to substitute saline fluid for transfused blood is practicable. 3. That depletion, with simultaneous transfusion, is indicated in some cases of poisoning, notably

opium-poisoning, and, probably, for many conditions not yet determined, by this process the vitiated blood being removed and the equilibrium of the vascular system restored. 4. That if in any case the admixture of more than an equal bulk of saline fluid with the blood in the connecting tube of the instrument be objectionable, fibrination may still be prevented by employing a smaller proportion of a more highly ammoniated solution than was used in these experiments.

[I receive confirmation in the belief that the syphon principle on which my instrument is constructed is the right one by the fact that it has been adopted by no less an authority than M. Roussel. The diagrams (p. 83) show—first, M. Roussel's well-known instrument; and, secondly, his modification of it, which has been illustrated in a recent number of the *Journal de Médecine de Paris.*]

ARTIFICIAL CIRCULATION AS A MEANS OF RESUSCITATION AFTER APPARENT DEATH.

Reprinted from the *Lancet*, February 7th, 1885.

I. *Chloroform Poisoning.*

THOSE experiments which were published in the *Lancet*, September 1st, 1883, being insufficient to demonstrate several points in connection with transfusion which requires elucidation, I have, at the suggestion of Sir Spencer Wells, performed a series of experiments upon dogs at Ghent. As elsewhere stated,* the experiments performed in Dr. Pye-Smith's laboratory at Guy's Hospital having indicated that transfusion of blood and the intravenous injection of saline fluid might be invaluable in certain cases of poisoning, the

* *British Medical Journal*, April 26th, 1884.

opportunity seemed favourable for testing the efficacy of the plan I have suggested where poisoning has occurred from the administration of chloroform. To M. Nuel, for the use of his laboratory at Ghent, and to MM. Boddaert van Custem, Van Duyse, Van Imschoot, Cleays, and Adenaw, for unwearying assistance in this work, my lasting obligations are expressed. I desire particularly to refer to Dr. Ringer's paper in the *Lancet* (1883, vol. i., pp. 628-9), "Concerning the Effects of Dilution and Concentration on the Action of Poisons;' and to Dr. B. W. Richardson's paper on "Death from Chloroform," in the *Medical Times and Gazette* (1870, vol. ii., pp. 85-6), and to his communication to the Royal Society in 1865 on the "Possibility of Restoring the Life of Warm-blooded Animals," etc., wherein a method of artificial circulation is described.

Experiment 1.—Repetition of the experiments already referred to (q.v.), to demonstrate the method of transfusion of blood and saline fluid, with subsequent repletion of the donor with saline fluid. July 16th, 1884, 4.30 p.m.: Weight of giver, 47·35 lb. Weight of receiver, 40·74 lb. Hypodermic injection of morphia (3 gr.) for each dog. Coma becoming quickly profound in the receiver, $\frac{1}{60}$ gr. atropine was subsequently injected into this animal. Transfusion was established between the right external jugular veins of the dogs, the receiver being simultaneously depleted on the cephalic side of the cannula. The saline fluid employed (temperature 78° F) contained rather less than half a minim of liquor ammoniæ to each ounce. After the transfusion of blood and saline fluid, the giver was repleted with saline fluid. The entire quantity of saline fluid injected into the dogs was 46·9 oz. Chloroform was the anæsthetic employed. After the experiment the donor had gained 3 oz. $230\frac{3}{4}$ gr.; since also this dog had vomited considerably after it was first weighed, the injection of saline fluid was still more in

excess of the quantity of blood lost by transfusion. The receiver gained 21 oz. 162 gr. Thus it will be seen that in order to demonstrate the important point that blood would not coagulate in the instrument *in transitu*, the transfusion was very abundant, that the test might be a crucial one, and it appeared: (1) That the admixture of saline fluid with blood was capable of rapid and precise regulation; (2) that when the quantity of blood passing through the connecting tube is considerably less than the saline fluid, the former flows as a core, or as strands within the latter medium, the saline fluid being of the lighter specific gravity. Thus protected, the blood is not subjected to friction along the inner surface of the tubing. The transfusion of blood and the quantity of saline fluid injected into the receiver having been so great, it seemed probable that this dog might eventually perish from disorganization of the corpuscles, and it was decided to repeat the experiment, keeping the injection of the saline fluid within the bounds of safety. And since the amount of saline fluid which can be safely substituted for blood holds a definite ratio to the quantity of blood in the body (the substitution may be carried to the extent of about one-fifth of the blood in man), it is clear that the experiment cannot be pushed so far on a small dog as the injection of saline fluid can be carried with safety in actual practice on human beings. The receiving dog died on July 30th. The autopsy showed that the vessels were exceedingly engorged with fluid blood of a dark colour. All the organs were engorged, especially the kidneys. Examined microscopically the kidneys did not exhibit notable changes. The animal was extremely fat, and there was fatty degeneration of the liver. The costal cartilages were firmly ossified. The dog was an old one, and had lost one eye. The dog which had supplied the blood recovered.

Experiment 2.—July 24th: The dogs each weighed about 12 lb. The receiver was depleted on the distal side of the afferent cannula to the extent of $8\frac{3}{4}$ oz. Transfusion of blood and saline, followed by repletion of the giver with saline fluid. Forty-four ounces of saline fluid at 85° F., with 20 minims of liquor ammoniæ, were injected into the dogs. This experiment confirmed the preceding; it was performed under mixed narcosis. The apparatus was now washed and taken to pieces; the vein of the giver was ligatured, and the wound closed with sutures. On attempting to tie the vein of the receiver, the animal, having recovered from the anæsthetic with unusual rapidity, struggled. Chloroform was administered with a small supply of air. The dog held its breath for a few moments, suddenly took three or four short inspirations, and (apparently) died instantly. It was proposed to attempt reanimation by means of injecting an ammoniated fluid towards the heart, and depleting from the distal side of the cannula. The apparatus was put together, and the saline fluid which had been prepared for the experiment just performed being exhausted, and there being no hot water at hand, cold distilled water, to which a few drops of liquor ammoniæ had been added, was injected into the jugular vein. The dog was depleted simultaneously. There was no response, and though the time before the operation was commenced was not noted, it was certainly considerable, as will appear from the description which has been given. As a last resort, 4 minims of liquor ammoniæ were injected by a syringe into the rubber tubing of the syphon, near the cannula, whilst the fluid was flowing. Instantly the heart's action was restored. The heart sounds, as heard by the stethoscope, were exceedingly rapid and forcible. The circulation was re-established; the pulsations of the arteries were very strong and fast; muscular contractions occurred.

Artificial respiration was tried, but normal respiration was never resumed. The dog probably died from ammonia poisoning. The experiment with regard to resuscitation after chloroform poisoning was complicated in that it was performed after the dog's blood had been diluted by the previous transfusion of blood and saline fluid, and would not, therefore, tolerate the further dilution which the method of saline intravenous injection with simultaneous depletion involves. The blood-giver recovered perfectly.

Experiment 3.—This was undertaken to test the value of the intravenous injection of an ammoniated saline fluid, with simultaneous depletion, for chloroform poisoning. The apparatus used was a simple syphon (Fig. 1) charged with saline fluid, containing a small percentage of ammonia. Near the cannula was a T-shaped glass interruption (inverted), the additional limb being surmounted by a short rubber tube and burette clip. This T-tube served not merely the purpose of an air-trap, but, by means of a syringe, a solution of ammonia stronger than that contained in the syphon could be injected into it at pleasure. On July 25th, at 2 p.m., $1\frac{1}{2}$ gr. of morphia was injected subcutaneously into a dog weighing 14·31 lb. At 2.30 the coma was very profound; $\frac{1}{120}$ gr. of atropia injected. At 3.30 chloroform was administered on a towel by Dr. Boddaert very freely, with a small supply of air, till respiration and circulation had ceased. The tongue was then drawn out of the mouth and artificial respiration performed. Respiration and circulation were re-established. Chloroform was given again very freely. The respiration and circulation again stopped. Artificial respiration was performed. Respiration and circulation were again restored. Chloroform was again exhibited. The circulation and respiration ceased, and could not be restored by the performance of artificial respiration. The right external jugular vein was now exposed and

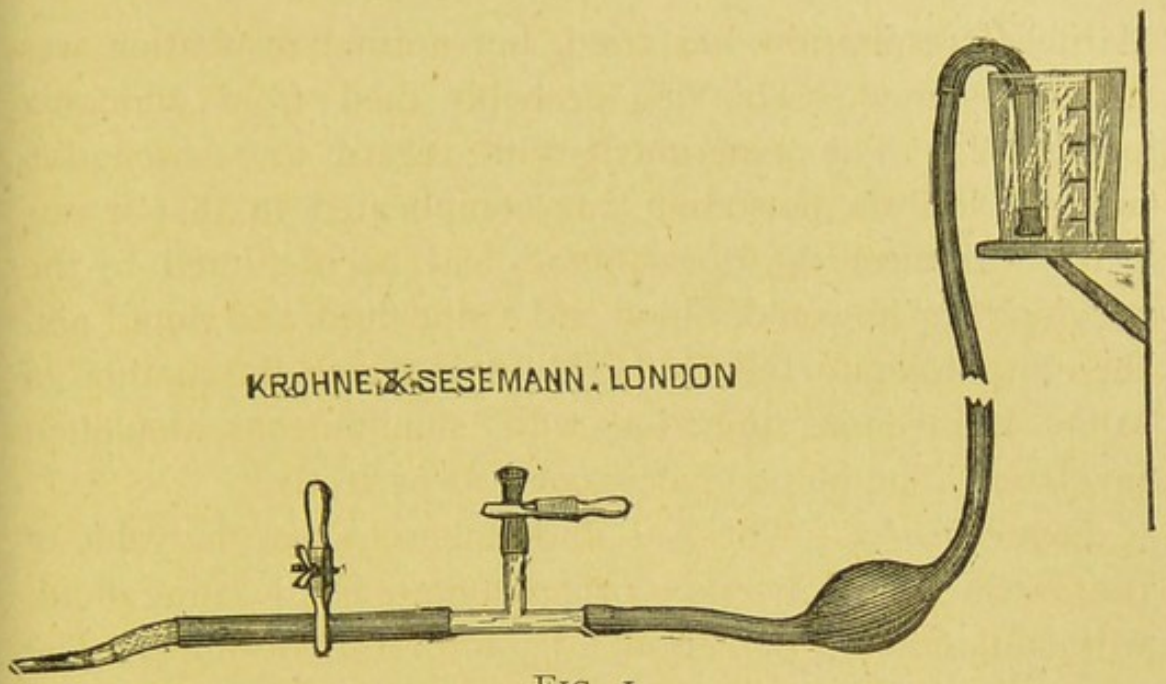


FIG. 1.

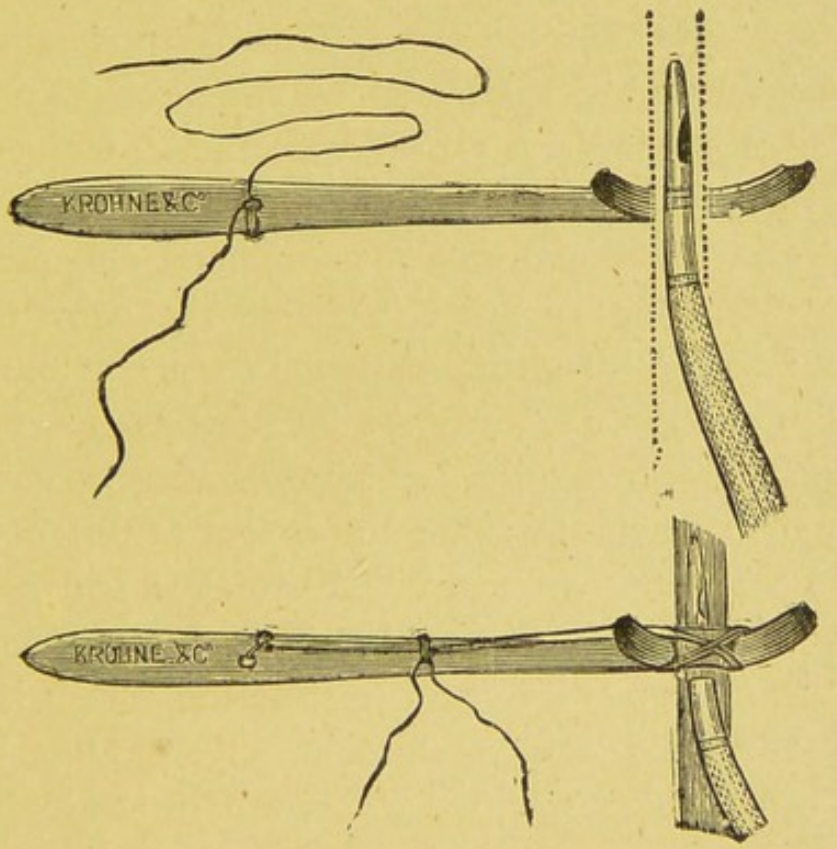


FIG. 2.

grasped with a Wells's forceps at a point corresponding to the centre of the incision. The cannula of the syphon was inserted, by the help of a phlebotome, into the vein on the cardiac side of the forceps. The cannula was secured in its place within the vein by the application of a cannula pin and waxed ligature (Fig. 2), that it should not slip. The vein was opened on the distal side of the forceps. The quantity of blood drawn was about $8\frac{3}{4}$ oz. (besides a good deal wasted), and the quantity of the saline fluid injected was about 21 oz. at 90° F., containing $10\frac{1}{2}$ minims of liquor ammoniæ. One minim and a half of liquor ammoniæ was also injected by the syringe. The intravenous injection and depletion were quickly followed by restoration of the circulation. Artificial respiration was now sedulously performed, and reanimation became perfect. The dog gained by the experiment about one-third of a pound in weight. This animal completely recovered. Since the injection and depletion appeared to have been carried further than necessary, it was decided to repeat the experiment, and to draw a little blood after the intravenous injection had been commenced.

Experiment 4.—July 25th: A black-and-tan dog; weight, 13·1 lb. 2 p.m.: Hypodermic injection of morphia, $1\frac{1}{2}$ gr. 2.30: Atropia, $\frac{1}{120}$ gr. At about 5 p.m. the dog was poisoned with chloroform, and after the circulation and respiration had ceased, artificial respiration was ineffectually tried. After opening the external jugular vein with the phlebotome, the cannula, first entering between the vein and its sheath, was withdrawn. Blood escaped from the aperture in the vein, and a convulsion occurred. The aperture was now grasped with forceps, and the cannula inserted into the vein on its cardiac side. Ammoniated saline fluid was injected into the vein, but there was no return of animation. Depletion on the distal side of the cannula was tried, and the blood,

which hardly flowed at first, was of a dark colour and tarry consistence. More saline fluid was injected, and 3 minims of liquor ammoniæ by the syringe. No signs of reanimation appeared. Artificial circulation was carefully performed, and altogether 23 oz. of saline fluid were injected. The quantity of blood drawn was not measured. On examining the heart, post mortem, its cavities were greatly distended with coagulated blood. It was resolved to repeat the experiment, but to deplete freely in the first instance, in order to relieve the heart and cerebral vessels of all engorgement.

Experiment 5.—July 27th: Weight of dog, 11 lb. 3.15 p.m.: Injection of morphia, 1 gr. At 3.45 chloroform was freely administered on a towel with a small supply of air. The anæsthetic was exhibited for about a quarter of an hour, the respiration becoming shallower and fewer in number, and the pulse feebler towards the expiration of that period. At 4.1 the respiration ceased entirely. At 4.2 20 sec. the femoral pulses, which Dr. van Duyse and myself had been carefully feeling, ceased. The tongue was now drawn out forcibly with artery forceps, and artificial respiration was performed. Signs of animation not appearing, the operation was begun. A cannula was introduced as quickly as possible into the right external jugular vein, and tied therein. The dog was depleted on the distal side of the cannula, but the blood at first ran slowly, and was of a very dark colour. At 4.5—*i.e.*, 2 min. 40 sec. after the heart had ceased to beat—the injection of 8 oz. 7 dr. of saline fluid at 90° F., with about 4 minims of liquor ammoniæ, was commenced. Artificial respiration was persisted with. The flow of the blood became freer and of a brighter colour. Return of pulsation in the arteries was noticed at 4.10 precisely. Therefore the pulsations had been absent during a period of 7 min. 40 sec. The pulsa-

tions were now so forcible that it was feared a poisonous dose of liquor ammoniæ had been injected, but such was not the case. At about 4.30, after the experiment was concluded, the dog on being released ran about briskly. The amount of blood lost by depletion was not measured accurately, some being spilled. It probably was between 6 and 8 oz. 5 p.m.: It was noticed that whilst the dog walked about curious tetanic contractions of the muscles of the extremities occurred. This point is of importance, for it has been shown that the injection of ammonia into the veins in a toxic dose causes tetanic spasms, which cannot be distinguished from those produced by strychnia.* This animal recovered satisfactorily.

Experiment 6.—July 27th, 3.15 p.m.: 1 gr. of morphia was injected subcutaneously into a dog weighing 16·5 lb. The administration of chloroform was commenced at 6.15. The pulse became intermittent at about 6.34, and ceased entirely at 6.34 30 sec. The respiration ceased at the same time as the pulse, and could not be restored by artificial respiration, the tongue having been drawn out. Depletion with the injection of an ammoniated saline fluid (34¼ oz.) was performed at 6.38—*i.e.*, 3½ min. after apparent death. No signs of animation ever appeared. Probably the operation was begun too late after the cessation of the pulse. Further, at the commencement of the infusion the flow of blood was arrested by a coagulum which formed at the aperture made in the vein on the distal side of the cannula; so that what occurred in Experiment 4 took place here also—viz., that the heart, already paralysed by the chloroform, was distended by the infusion, which was in excess of the depletion. This hypothesis was supported by an examination of the heart and lungs, which were found to be enormously engorged. The quantity of blood lost—

* Richardson, "Cause of the Coagulation of the Blood," p. 440.

but not at the outset—was great, but, as already intimated, not so great as the quantity of fluid injected.

Experiment 7.—July 28th, 10.50 a.m.: 1 gr. of morphia was injected into a dog, which weighed 18 lb. Chloroform was administered at 11.30. The pulse became irregular at 11.36, and ceased just before the respiration at 11.40. After the tongue had been withdrawn by artery forceps, and after artificial respiration had been ineffectually tried, the right external jugular vein was exposed and grasped with forceps. The animal was bled on the distal side of the forceps, and a cannula was inserted into the vein on the proximal side. At first it seemed doubtful whether the cannula was properly inserted within the vein; it was therefore withdrawn and inserted in the left external jugular vein. The depletion and injection of nearly 30 oz. of saline fluid at 100° F., with 15 minims of liquor ammoniæ, were commenced at 11.43—*i.e.*, three minutes after apparent death. Four minims of liquor ammoniæ were injected later on by means of the syringe. Artificial respiration was performed concurrently with the maintenance of the circulation; but pulsation not returning, the region of the fauces and larynx was inspected. It was noticed that comparatively little air entered the lungs during their expansion, owing to the fact that the epiglottis, which was flaccid, was drawn down like a valve over the superior orifice of the larynx. The epiglottis was drawn forward with another artery forceps, and in a few seconds, at 11.55—*i.e.*, fifteen minutes after apparent death—forcible pulsations were detected in the femoral arteries. Contractions of the muscles of the jaws occurred, and also of those of the extremities. The mouth being closed, and the forceps which grasped the epiglottis having been necessarily removed, the indication seemed to be tracheotomy, which was at once performed. But the action of the heart suddenly stopped, and life

departed. An autopsy showed that the heart was distended with fluid blood, save a small coagulum on the mitral and tricuspid valves. The vessels were engorged. This report justifies the belief that had tracheotomy been performed simultaneously with the injection and depletion, or, what amounts to the same thing, had the epiglottis been drawn forwards at the onset, life would have been restored. As it was, the artificial respiration was only effectually carried out some fourteen minutes after apparent death, and after the blood had been too diluted to perform satisfactorily its functions. In such a case, transfusion of blood might meet the difficulty.*

Experiment 8.—July 29th, 2 p.m. : One grain of morphia was injected into a terrier weighing 14·38 lb. The administration of chloroform was commenced at 3.34 p.m. When the animal was anæsthetised, a ligature was passed through the tongue. It was noticed that firm traction on the organ did not satisfactorily withdraw the epiglottis, which can be readily seen in the dog. A ligature of fine silk was passed through the epiglottis by means of a small curved needle, so that traction could be made on the epiglottis directly. Respiration stopped at 3.46 p.m. The pulse stopped at 3.51 p.m. The right external jugular vein was now exposed, and the cannula inserted. Depletion showed that the blood was not nearly of so dark a colour as that drawn in the previous experiments ; doubtless owing to the access of air to the lungs afforded by traction on the epiglottis. Altogether 20 oz. of saline fluid (temp. 90° F.) with ten minims of liquor ammoniæ were injected. Artificial respiration was continued, and normal respiration returned at 4.2 p.m., the circulation being re-established first : in fact, very shortly after the saline injection was commenced. The blood lost by depletion was partly caught in a porcelain dish, but a

* *Vide infra*, Experiment 15.

considerable quantity escaped beneath the dog, and some also ran through perforated holes on the table to a shelf below. The experiment was therefore carried further than was necessary to restore animation, and afterwards, when the quantity of blood lost, which was in excess of the saline liquid injected, was examined, it was clear that sufficient had not been left within the vessels to maintain life for more than a short period. This experiment was performed by Dr. Boddaert and myself. At 6 p.m. it was reported by one of the laboratory porters that the dog had been "dead" for some time, probably for about fifteen minutes. The body was quite warm, but respiration and circulation had certainly ceased, and the forelegs were stiff. Half a minim of liquor ammoniæ with twenty minims of water were injected directly into the left ventricle through the chest-wall, and the injection was immediately followed by a return of pulsation. The tongue was drawn out of the mouth, and the epiglottis grasped with artery forceps. The laboratory porters were directed to perform artificial respiration whilst I prepared a saline solution. On exposing the left external jugular vein, that vessel was found much collapsed; twelve ounces and three drachms of saline fluid were injected. (Transfusion of blood was strongly indicated here, for the animal was dying from hæmorrhage, and the blood in the body was already very much diluted. Nevertheless, it seemed better to inject saline fluid instead, and to watch the result, rather than complicate the experiment further.) The hind-legs of the animal were bandaged firmly and elevated, in order to drive the blood towards the vital centres. At 6.30 p.m. the dog was placed before a stove, and half a drachm of brandy with an equal quantity of water, and $\frac{1}{120}$ of a grain of atropia were injected subcutaneously. At 7 p.m. the pulse was 96, and six deep inspirations were taken per minute. The dog died at 10 p.m. The autopsy

made the following day showed that the left ventricle was firmly contracted. Not much blood was found in the vessels, and it was entirely fluid. There was a small extravasion (caused by the point of the syringe) beneath the visceral pericardium. Death evidently occurred from paucity of blood, and a comparison of this experiment with Experiment 15 fully justifies the opinion that had transfusion of blood been performed prior to 10 p.m. on the previous evening, life would have been saved.

Experiment 9.—To determine whether the intravenous injection of fluid (with simultaneous depletion) performed shortly after apparent death excited the heart to pulsation by stimulating the organ itself—either the intrinsic ganglia of the heart or its muscle fibres—or by stimulating certain ganglion cells in the medulla. July 30th, 2.30 p.m.: 1 grain of morphia was injected subcutaneously into a dog weighing 11 lb. At 3 p.m. chloroform was administered, the tongue and epiglottis were drawn forwards, and a cannula was inserted into the right external jugular vein towards the heart. The animal was then destroyed by pithing the medulla, and immediately afterwards saline fluid (with half a minim of liquor ammoniæ to each ounce) was injected into the vein, simultaneous depletion being practised, and artificial respiration being maintained. Altogether about 40 oz. of ammoniated saline fluid (temperature 90° F.) were infused, and three minims of liquor ammoniæ were injected by means of the syringe. The heart continued to beat till most of the blood had been expelled from the body. Inspection of the heart and vessels showed that they were filled with saline fluid tinged with blood. The experiment was unsatisfactory in this respect, that after the medulla was destroyed, observation was not made as to whether the heart actually stopped. So that it cannot be asserted that the circulation was re-established by the infusion and depletion,

but it can be said that, by the procedure, the circulation was well maintained. It is a physiological fact that after destruction of the medulla the heart's action does not instantly cease. But I do not think that in this experiment the circulation would have been maintained so long or so strongly without the saline injection. There was no violent action of the heart after the injection of the ammoniated fluid such as has been noted in some of the preceding experiments. Therefore this experiment indicates that, after apparent death, the infusion of a saline ammoniated fluid accompanied by depletion, if it produce reanimation at all, acts in a two-fold manner—(1) by directly stimulating the heart—whether its muscle fibres only, its intrinsic ganglia, or both, are distinct questions; and (2) by stimulating certain ganglion cells in the medulla.

Experiment 10.—Infusion with depletion for chloroform poisoning. July 30th, 2.30 p.m.: 1 grain of morphia was injected subcutaneously into a dog of 15·2 lb. weight. 4.10 p.m.: Chloroform administered. The tongue and epiglottis were drawn forward. Pulse 105 per minute. The anæsthetic was given freely with plenty of air. 4.24 p.m.: The respiration stopped. 4.27 p.m.: The pulse stopped. 4.32 p.m.: Infusion and depletion were commenced, and artificial respiration was performed. Altogether nearly 40 oz. of saline fluid (with a quarter of a minim of liquor ammoniæ to each ounce) were injected. Two minims of liquor ammoniæ were also injected by the syringe, and subsequently half a minim of liquor ammoniæ with a little water was injected directly into the left ventricle. No signs whatever of reanimation occurred. Some of the fluid was injected into the left common cartoid artery, after the injection into the jugular vein had failed.

Autopsy.—The vessels and heart were moderately filled with blood and fluid. The ventricles were dilated.

Observations.—(1) The blood in this experiment was very thoroughly impregnated with chloroform; (2) the infusion and depletion were not commenced till five minutes after the pulse, and eight minutes after the respiration had failed; (3) only half the quantity of liquor ammoniæ had been employed in the saline fluid, as compared with that used in the other experiments.

Experiment 11.—August 1st, 10 a.m.: 1 grain of morphia was injected into a dog of 11·12 lb. weight. At 10.21 a.m. chloroform was administered, and the tongue and epiglottis were drawn forwards 10.30 a.m.: The pulse became intermittent. 10.34 a.m.: The pulse stopped entirely, and the respiration directly afterwards. After an interval of less than a minute the operation was commenced. Depletion and injection with artificial respiration were performed as in the other experiments. The pulse returned at 10.43 a.m.—*i.e.*, after a cessation of nine minutes. Normal respiration recommenced at 10.47 a.m. At 11.7 a.m. the pulse was 52, and the respiration was 40 per minute. Altogether nine ounces of saline fluid, at 100° F. (with three-quarters of a minim of liquor ammonia to each ounce) had been infused, and one minim of liquor ammoniæ had been injected by the syringe. The depletion was considerably less than the infusion, for after the experiment the dog weighed 11·38 lb., and had, therefore, gained more than a quarter of a pound in weight. This animal recovered perfectly.

Experiment 12.—August 1st, 11.40 a.m.: 1 grain of morphia was injected subcutaneously into a dog weighing 7.05 lb.. 11.58 a.m.: Chloroform was administered. The tongue and epiglottis were drawn forward. 12.3 p.m.: The pulse became intermittent. At 12.5 p.m. the pulse and respiration stopped; but returned after the performance of artificial respiration. Chloroform exhibited again. At 12.8 p.m. the pulse and respiration ceased, and did not re-

turn after the renewal of artificial respiration. Depletion, with injection of saline fluid into the external jugular vein was made at 12.9 p.m. The pulse returned at 12.11 p.m., and normal respiration thirty seconds later. At 12.45 p.m. the pulse was 76, and the respiration was 60 per minute. This animal recovered. The quantity of saline fluid infused was nine ounces, and contained three-quarters of a minim of liquor ammoniæ to each ounce. One minim of liquor ammoniæ was also injected by the syringe. The infusion was in excess of the depletion, for after the experiment the dog weighed 7·35 lb.—*i.e.*, it had gained about a third of a pound by the experiment.

Remarks.—The preceding experiments show that if depletion and intravenous injection be performed quickly after apparent death (*i.e.*, before coagulation of the blood has commenced—and it commences early in cases of chloroform poisoning), pulsation will be restored. Experiment 2 has demonstrated, also, that if chloroform poisoning occur where the blood is in a diluted and *fluid* condition (and fluidity can always be attained by the exhibition of ammonia, as proved by Dr. Richardson), pulsation may be restored some minutes after apparent death by the operation. The only reasonable explanation of these phenomena is that the "vital centres" do not necessarily perish with the cessation of pulse and respiration; and if the circulation and respiration can be restored—a thing always possible, provided the blood be fluid—the vital centres will often resume their functions, even after they have been suspended for a period of some duration. It was resolved to repeat the last experiment, allowing a lengthy interval to elapse after apparent death before attempting to restore the circulation; and in subsequent experiments to exhibit ammonia before the administration of chloroform, that the blood might be kept fluid after the signs of animation had departed.

Experiment 13.—August 1st, 3 p.m.: Half a grain of morphia was injected into a dog of 9·8 lb. weight. Chloroform was administered at 3.49 p.m. The pulse became intermittent at 3.54 p.m.; it stopped completely once or twice, but was restored by artificial respiration. Finally, the pulse and respiration ceased at 4.2 p.m. The injection and depletion were commenced at 4.4 30 sec. or 4.5 p.m. In the interim M. Nuel kindly made an ophthalmoscopic examination, and afterwards wrote for me the following note: "La choroïde était tout à fait exsangue. Les petits vaisseaux rétiniens n'étaient pas visibles (ils étaient vides). Mais les gros vaisseaux rétiniens renfermaient du sang; seulement les colonnes sanguines étaient interrompues à la périphérie de la papille." Altogether 30 oz. of saline fluid (containing 22 minims of liquor ammoniæ) were infused, and two minims of liquor ammoniæ were injected by the syringe. This was about three minutes after signs of life had disappeared. The blood which flowed from the vein was partly coagulated, and very dark in colour. No return of pulsation occurred.

Experiment 14.—August 4th, 9.40 a.m.: 1 grain of morphia was injected into a dog of 16·21 lb. weight. At 9.55 a.m. the pulse was 83 per minute. 9.57 a.m.: Hypodermic injection of three minims of liquor ammoniæ in a little water. 10.5 a.m.: Pulse 56 per minute. 10.10 a.m.: Injection of ammonia repeated. 10.30 a.m.: Pulse 50 per minute. 10.39 a.m.: Chloroform was administered. 10.46 a.m.: Irregularity of the pulse. 10.47 a.m.: The pulse stopped. 10.47 30 sec. a.m.: Respiration stopped. 10.49 30 sec. a.m.: Injection and depletion commenced; artificial respiration was performed, with the tongue and epiglottis drawn forwards. 10.56 a.m.: Pulse returned. 10.58 a.m.: Normal respiration returned. At 11.20 a.m. the pulse was 40 and the respiration 14 per minute. Thir-

teen and a half ounces of saline fluid at 96° F. (with three-quarters of a minim of liquor ammoniæ to each ounce) were infused. On minim of liquor ammoniæ was injected by the syringe. After the experiment the dog was found to have gained about ·15 lb., therefore the infusion was in excess of the depletion. The animal recovered.

Experiment 15.—Aug. 4th, 11.33 a.m.: One grain of morphia was injected subcutaneously into a dog of 27·09 lb. weight. 11.37 a.m.: Hypodermic injection of six minims of liquor ammoniæ in water. 11.49 a.m: Administration of chloroform. The epiglottis and tongue were drawn forward. 11.53 a.m.: The pulse became intermittent. 11.56 a.m.: The pulse stopped. 11.58 a.m.: The respiration ceased. 12.4 p.m.: Injection and depletion, with artificial respiration. 12.5 20 sec. p.m.: Pulse returned. (Therefore pulsation was absent during a period of 9 min. 20 sec.) 12.3 35 sec. p.m.: Normal respiration was established. At 12.35 p.m. the pulse was 36 and the respiration 20 per minute. Nearly 9 oz. of saline fluid were infused, with three-quarters of a minim of liquor ammoniæ to the ounce (temperature 96° F.) Ammonia was not injected by the syringe. After the experiment the dog weighed 25·77lb.—*i.e.*, it had lost 1·32lb. The excessive loss of blood was due to two circumstances—first, considerably more blood flowed during the operation than was intended, and secondly, hæmorrhage occurred from the jugular vein after the infusion and depletion, owing to the slipping of a ligature. From the figures which have been given, it will be seen that though the dog had recovered from the toxic effect of the chloroform, yet its life was jeopardised by the quantity of blood which had been lost. In such a case as this, nothing but transfusion of blood would prevent death (cf. Experiment 8). However, there was no immediate danger, and the operation of transfusion was therefore postponed till

that time had elapsed which, in actual practice, would be required to obtain a blood-giver. In the afternoon a large quantity of blood with a little saline fluid—for the blood of the animal was already much diluted—was transfused into the left femoral vein. Ether and a little chloroform were employed for the receiver, and chloroform was administered to the giver during the operation. Ammonia was not added to the saline fluid, because the blood of the receiver was already highly ammoniated. After the transfusion, saline fluid was infused into the giver.

Giver, weight 30·39lb. : 3.15 p.m. : Hypodermic injection—morphia, 2 grs. ; atropia, $\frac{1}{96}$ gr. 4 p.m. : Transfusion, followed by repletion with saline fluid. Weight after experiment 29·84 lbs. ; therefore loss = ·55lb.	Receiver, weight 25·77lb. : 4 p.m. : Pulse 36 per minute; shivering. After the transfusion of blood and saline fluid the animal weighed exactly 27·09 lb., which was its original weight.

During the experiment 24 oz. 5drs. of saline fluid (temperature 85° F.) were employed. Both animals recovered.

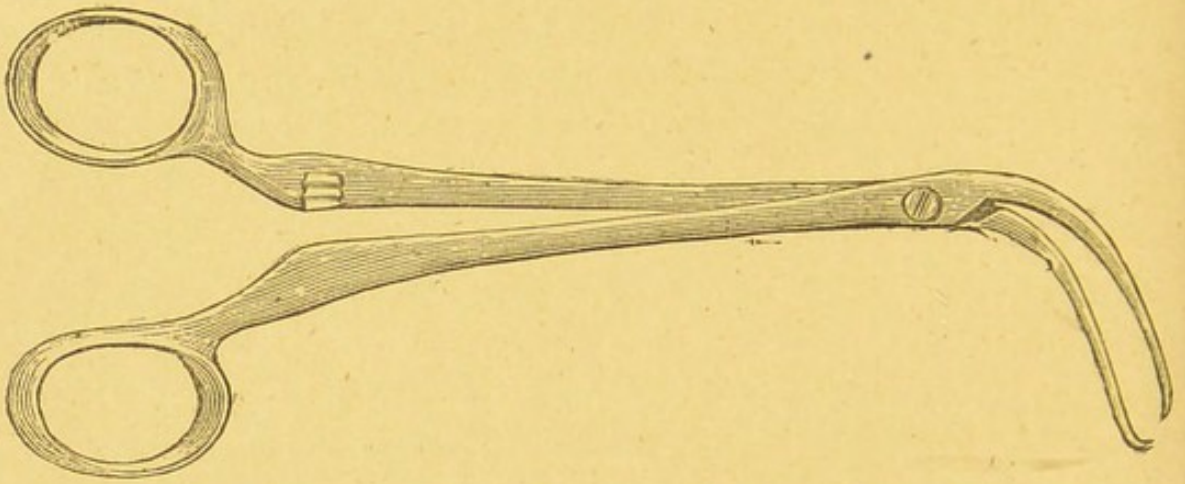
Experiment 16—Aug. 5th, 10 a.m. : A grain and a half of morphia was injected into a dog of 26·32 lb. weight. Six minims of liquor ammoniæ, in a little water, were also injected subcutaneously. 10.40 a.m : Administration of chloroform. 10.50 a.m. : The pulse became intermittent. 10.50 30 sec. a.m. : The respiration ceased. (The tongue and epiglottis had fallen back, and were now both drawn forward. Artificial respiration was performed till 10.58 a.m.) The pulse stopped at 10.55 a.m. 11.4 a.m. : Depletion and injection of saline fluid at 100° F. (with three-quarters of a minim of liquor ammoniæ to the ounce) into the right external jugular vein. There being no response to the in-

jection—performed nine minutes after the cessation of the pulse,—the cannula was removed, and inserted into the left carotid artery (towards the heart) in order to inject the coronary arteries. No response. The cannula was then removed, and reinserted towards the cerebrum (11.34 a.m.) when muscular movements over the face and neck occurred. No other signs of animation.

Experiment 17.—Aug. 5th, 11.45 a.m.: A dog weighng 21·8 lb. Half a grain of morphia and five minims of liquor ammoniæ in water were injected subcutaneously. 12.9 p.m.: Administration of chloroform. 12.13 p.m.: Respiration stopped. 12.14 15 sec. p.m.: Pulse stopped. 12.22 p.m.: Injection of ammoniated saline fluid into the carotid artery, towards the cerebrum. Simultaneous depletion from the external jugular vein. Muscular twitchings over the face occurred. The jaws were closed, the eyelids were opened and shut, but no other signs of animation were observed.

Remarks.—All surgeons are aware that death from the administration of chloroform occurs either by asphyxia or by "paralysis of the heart." If death take place from asphyxia, the asphyxia is almost always an epiphenomenon. The tongue falls back, the laryngeal musculature is paralysed, the epiglottis drops over the superior aperture of the larynx. If the tongue be drawn forward and artificial respiration be now performed, a little air will enter the lungs, but not very much, for the epiglottis is flaccid, and at each inspiratory movement of the chest is drawn down like a valve. If the tongue be drawn out of the mouth forcibly with artery forceps, as advocated in Holmes's "System of Surgery" by Sir Joseph Lister, more air will enter the larynx, around the tip and edges of the epiglottis; but the access of air to the lungs is by no means free. This can be readily demonstrated on the dead body if a vertical section be made of the head and neck; and the foregoing experiments have

conclusively proved the accuracy of this statement. If, therefore, life be threatened by asphyxia during anæthesia, and any impediment be noticed to the entrance of air to the lungs during artificial respiration, either tracheotomy should be performed or the epiglottis should be drawn forward with forceps. On dogs the latter object can be easily effected with common artery forceps. Owing to the different configuration of the parts in man as contrasted with the dog, I have had forceps for the epiglottis made, which, as will be seen from Fig. 3, follow Sir Spencer Wells's forceps with regard to the handle, and artery forceps in respect to the point. Mr. Marshall has informed me that in one case he



performed tracheotomy with success for asphyxia consequent on anæsthesia; and the sudden rush of air into the trachea demonstrated the necessity for the operation. A similar rush of air is noticed when the epiglottis is drawn forward under like circumstances, and the only superiority of tracheotomy over traction on the epiglottis is that it is perhaps more speedy, and a freer access of air would be gained to the lungs because the sectional area of the opening made in the trachea would be greater than that of the rima glottidis. The arguments to be adduced in favour of the choice of traction on the epiglottis are that by direct experiment the method has been proved successful, and

that by it tracheotomy can be avoided. If death be imminent during chloroform anæsthesia from "paralysis of the heart"—true chloroform poisoning, when, as a rule, the circulation ceases before the respiration—the maintenance of an artificial circulation is clearly the right line of treatment. Experiment 5 shows that if this plan be adopted within 2 min. 40 sec. after apparent death, life can be saved. Further, if ammonia be exhibited prior to the administration of chloroform, life may be saved, as shown by Experiment 15, if the injection be made within eight minutes after cessation of the pulse, and six minutes after cessation of the respiration. Clearly, the practical point is to give a full dose of sal volatile before commencing the administration of chloroform, in order that, should an accident occur, time may be gained. The greatest danger exists when the patient, from dread of the anæsthetic, struggles and holds the breath for some seconds or more till the blood is carbonised, and then takes a few short, deep inspirations. Only too often a small but concentrated quantity of the vapour suddenly enters the lungs, and the pulse and respiration abruptly stop. Attention having been first paid to the access of air to the lungs, the external jugular vein should be instantly exposed and grasped in the lower angle of the wound with Wells's forceps. The vein can now be opened on the cephalic side of the forceps, so that artificial respiration can be performed without the risk of admitting air to the vein. The experiments embolden me to state that if this method be adopted promptly, reanimation would almost certainly follow the venesection. If the circulation be not re-established at once, the only remaining chance of safety would lie in the infusion of saline fluid, with or without the cautious use of ammonia. Since the dread of anæsthesia can always be prevented by the subcutaneous injection of morphia, it is difficult to understand why that alkaloid is

not employed more frequently than it is, in a full dose, before the administration of chloroform. Atropia might be most advantageously combined with the morphia, since physiology teaches that atropia prevents inhibition of the heart through the vagus.

"Artificial circulation" having been treated by previous writers, I desire particularly to refer the reader to Dr. B. W. Richardson's paper on "Restoring the Life of Warm-blooded Animals," to a paper by the same author on "Death from Chloroform," and to Dr. Ringer's communication concerning the "Effects of Dilution and Concentration on the Action of Poisons." And since the research which forms the basis of the present communication has been conducted apart from preconceived ideas, the opinions deduced therefrom will be found in some respects to confirm, and in others to antagonise, the views of the distinguished men who have already worked at the subject.

THE INTRAVENOUS INJECTION OF MILK.

Reprinted from the *British Medical Journal*, June 6, 1885.

HAVING recently injected milk into the veins of a patient about to die,* who survived for some hours after the operation, and believing that this therapeutic measure is one of great value as a substitute for the transfusion of blood, I have perused most of the literature on the subject, and find that many of the operations have been followed by marked success; in some cases by temporary, and in others by permanent benefit; but sometimes no good has accrued from the injection (when improperly performed, or when

* The report of this case will be published in full in a later communication.

performed in unsuitable cases); and the operation appears to have proved fatal in a few instances.

But, the intravenous injection of milk having now been practised under a considerable variety of circumstances, and many of the reports having been drawn up with great accuracy, it may perhaps prove of utility to lay before the profession an outline of the history of this important plan of treatment, which is now seldom resorted to, with the view of showing that the indications for this method of conveying nutrition are generally clear, and that, if properly performed, no harm can follow the operation.

Dr. T. Gaillard Thomas, in a communication to the *New York Medical Journal*, 1878, urges the operation on physiological grounds, and compares the injection of milk into a vein with the normal passage of the chyle into the subclavian vein from the thoracic duct. "Chyle is fat in emulsion in a serous fluid; milk is fat, molecularly divided, and suspended in water with casein and sugar." Dr. Thomas also quotes an instance in which blood, drawn from an apoplectic subject after a heavy meal, yielded a "distinct and voluminous zone of white milky-looking fluid, a fluid which had evidently been previously mixed with the blood, and was now separated from it."

At a meeting of the Société de Biologie in Paris, Dr. Brown-Séquard gave an account of his experiments on transfusion. He had tried normal blood, defibrinated blood, and milk. In each case the result was the same, save that in the case of milk it was necessary to inject more than of the other fluids. Ninety-five grammes of blood were drawn from a dog, and replaced by ninety-five grammes of milk. About forty-five minutes afterwards there was no trace of milk-globules to be found in the blood. The dog continued in excellent health, and was alive at the time of the report (that is, five months ago). M. Malassez found,

on examining the blood after the transfusion, a greater quantity of white globules than normal. Dr. Brown-Séquard considered that the liquid injected should be at least of a temperature of 10° to 12° Cent. He preferred injecting into the arteries, and very slowly, to give time for the injected fluid to acquire the temperature of the body (*Lancet*, 1878, vol. ii., p. 641).

Experiments upon dogs have also been conducted by Wulfsberg. He injected about 250 grammes, and examined the blood to determine whether the globules of the milk (as Donné stated in 1884) were converted into white corpuscles. He found that the white corpuscles undoubtedly increased in number, but only after having first taken up—in fact, eaten—the milk-spheres. He could not preserve the life of dogs by this means: their weight diminished, they died without obvious disease, and he found hæmorrhagic infarcts in the lungs. If about ·75 per cent. of the estimated weight of the blood were injected, the dogs bore the injection well. Large injections proved rapidly fatal (*Lancet*, 1878, vol. ii., p. 823).

M. Laborde injected milk into the lymph-sac of a frog. The capillary circulation was studied microscopically in the interdigital web, in the tongue and mesentery; fatty globules were noticed to accumulate at the points of bifurcation of the capillaries (*British Medical Journal*, 1879, vol. i., p. 557).

The experiments of Drs. Moutard-Martin and Charles Richet show that, in animals killed by the intravenous injection of large quantities of milk or sugar, there is very marked intestinal injection, and sub-endocardiac ecchymoses are of constant occurrence. Death is preceded by polyuria (*Medical Times and Gazette*, 1879, vol. ii., p. 659).

Dr. J. H. Howe experimented on seven dogs, substituted milk for the blood—every dog died. He also tried

the lacteal injection upon a man in the third stage of phthisis, in whom death occurred from coma soon afterwards. But Dr. Thomas, having performed the operation on the human subject with success, and having ascertained that the milk employed in Dr. Howe's experiments had been drawn from a cow one or one and a half hour's distance by rail from New York, reaching that city after a lapse of two or three hours, requested Dr. Eugene Dupuy to repeat the experiments upon dogs. Dr. Dupuy's experiments showed (1) that the intravenous injection of decomposed milk into dogs is uniformly fatal; (2) that the same experiment, if practised with perfectly pure and fresh milk, is entirely innocuous (*New York Medical Journal*, May, 1878).

The experiments of Professor Schäfer also show that the intravenous injection of fresh milk in small quantities, or of milk boiled after standing, is harmless; but that it is most dangerous to employ ordinary milk not so boiled, and the ordinary London milk is especially deleterious (*Journal of the Obstetrical Society*, London, 1879 and 1880, vol. xxi., p. 316).

Turning from experimental to clinical evidence, Dr. Thomas reports (*American Journal of the Medical Sciences*, 1876, p. 61, *et seq.*) a case in which he removed two solid ovarian tumours. Profuse uterine hæmorrhage set in thirty-six hours after the operation, and the bleeding recurred in spite of plugging the vagina. Four days after the operation the temperature was 101°, the pulse 150; there were the Hippocratic countenance and other signs of impending dissolution. The intravenous injection of milk was decided upon, on the grounds that, in 1850, Dr. E. M. Hodder had injected milk into the veins of three cholera patients (in one case as much as fourteen ounces at one operation), two of whom, who appeared moribund at the time of the operation, recovered; that Donné had injected milk into the veins of

dogs and rabbits without injury; and that the intravenous injection of milk seemed to be surrounded with less difficulties than transfusion of blood. On these grounds eight and a half ounces of freshly-drawn milk were injected into the median basilic vein. After three ounces had been injected the patient complained that her head would burst, therefore the injection was continued more slowly. An hour later there was a rigor: the pulse was 150-160 per minute, the temperature 104°. The next day the pulse was 116, the temperature 99·25°. Good recovery followed.

Two further cases are recorded by Thomas (*New York Medical Journal*, May, 1878).

A. S.——, aged 22. Removal of a very large ovarian tumour; many adhesions. Within twenty-four hours from the completion of the operation acute peritonitis developed. Fourteen days later, a large abdominal abscess discharged itself, and more than one pint of pus escaped. Three days later still the patient appeared moribund. February 27th, 8 p.m.: Pulse, 152; temperature, 103·8°. There were mental aberration and a semi-comatose condition. The injection of milk (the quantity is not stated) was made into the right median basilic vein, through a funnel and tube and very small cannula. A hypodermic injection of brandy and sal volatile was also administered. At 10 p.m. there was a chill; at 11.30 the pulse was much improved; temperature, 100·8°. From the 28th, 9 a.m., there was improvement till March 1st. Then, as the strength again failed, a second injection of fifteen ounces of freshly-drawn milk was made into the left median basilic vein. The pulse fell fifteen beats and became stronger. On March 3rd, at midnight, the pulse was 160. Dr. Hunter injected six ounces of milk into another vein. 1 p.m.: Pulse, 190; temperature, 104°; the patient had a chill. March 4th, 8 a.m.: Temperature, 102°; pulse, 122. At 3 p.m. eight ounces of

milk were injected. At 6 p.m. : Temperature, 103·4° ; pulse, 152. March 5th, 6 a.m. : Pulse, 156 ; temperature, 102·8°. There was diarrhœa. The wound communicated with the intestine. At 11 a.m. eight ounces of milk were injected into the right radial vein. Death occurred at 1 p.m. Altogether, there were five injections of milk.

At the necropsy there was perforation (1) of the caput cæcum coli ; (2) of the sigmoid flexure, at a point twelve inches above the anus. There was peritonitis. The kidneys were large and fatty; their tissue was firm, but not congested; the capsules were not adherent. The pelves and calices contained large flakes of exfoliated epithelium. Scraping the cut surface of the kidneys yielded a thin purulent-looking fluid. The spleen was firm and normal ; the chest was not examined.

Dr. Thomas also removed another large ovarian tumour, and much hæmorrhage occurred from the breaking down of numerous adhesions. The hæmorrhage was not arrested at the time of the operation, and it persisted internally, after the abdominal wound had been closed. Five ounces of milk were injected into the median basilic vein. Death occurred in fourteen hours. The necropsy showed that more than a pint of blood had been poured out into the peritoneal cavity.

In a communication to the *British Medical Journal* (1881, vol. i., p. 228), Dr. Meldon states that he had then performed the operation twenty-five times. Twelve of his cases were phthisical patients, all of whom were moribund, and in all life was prolonged by the injection. In one of these cases of consumption the patient had apparently only a few hours to live, yet he recovered, and rallied for some months. The operation was repeated, and the patient again rallied; he at last succumbed. The diarrhœa of phthisis was invariably checked by the intravenous injection of milk. The

perspiration was first increased, next diminished, by the operation. Cough was always relieved. In phthisis the improvement is only temporary; the operation lengthens life a few months. Four were cases of pernicious anæmia; all were cured. In one of these cases the operation was repeated. Two were cases of exhaustion sequent to hæmorrhage (one was uterine hæmorrhage, the other recurrent hæmorrhage from a wound of the palmar arch); both recovered. Two were cases of exhaustion after typhoid fever. Both improved: one recovered, one died.

Dr. Meldon never injected more than six ounces of freshly drawn milk at a time, and added ten grains of carbonate of ammonia to each injection. As already stated, the four cases of progressive anæmia were cured by the nutritive injections; and Dr. Meldon considers that it can be easily understood how, in that disease, a small quantity of corpuscle-supplying fluid might alter the condition of the blood and thereby effect a cure (*Lancet*, 1880, vol. i., p. 527).

The intravenous injection of milk was first performed in Ireland by Dr. Robert McDonnell, on January 22nd, 1879. The patient was aged 30, and had been under the care of Dr. Meldon since November, 1878, suffering from typhoid fever. There were profuse diarrhœa, which could not be checked by the ordinary remedies, and extreme failure of the digestive powers. Death seemed imminent. Nearly ten ounces of milk, freshly drawn, were injected into the right median basilic vein. The pulse rose and became comparatively strong. Subsequently there were great respiratory disturbance and capillary injection. In about two hours these effects passed away, and the patient rallied wonderfully. The diarrhœa was checked, and six days later the man's condition was most satisfactory (*British Medical Journal*, 1879, vol. i., p. 165).

In the *Philadelphia Medical Times* of November, 1878 (*British Medical Journal*, 1879, vol. i., p. 557), Dr. W. Pepper gave a careful history of two cases of anæmia treated by the intravenous injection of milk. The first case was that of a woman aged 32. There were extreme anæmia, intense spinal irritability; no organic disease. No treatment seemed to do good. On June 20th, 1878, some freshly drawn milk (temperature 100°) was injected by Dr. Hunter, by means of a tube and funnel and sharp-pointed cannula, into a vein of the arm. Twenty grains of quinine were administered previously to the operation, with the view of counteracting the effects of chill. The funnel was held twenty inches above the arm. The first effects were violent capillary injection of the face and surface of the body. The eyes were prominent and injected; the lips became turgid, and the whole expression wild and alarming. There was laboured respiration, with intense depression. The patient clutched at her throat in distress. The funnel was therefore lowered; and, when the patient became easier, it was raised again. Eighteen minutes after the operation urticaria appeared, the wheals being large and pale-reddish in colour. This disappeared, but reappeared in ten minutes. The pulse at the time of the operation was 108; in five minutes, 150; then it fell to 128 at the time of the appearance of the urticaria. The pulse was 92 twenty minutes later; for several hours it remained at 95. She had a good night. The next day the woman was in her normal state. The urine was normal. The operation was repeated on June 27th and again on July 17th, with decided improvement as the result.

The second case was one of progressive anæmia in a sailor, aged 33. The corpuscular richness of the blood (by Malassez's method) was just over 25 per cent. of the normal. The proportion of white to red corpuscles was about 1 to 643, that is, reduced. On June 15th, 1878, at 12.35, six

ounces of milk were injected into the left median basilic vein. The first effect was flushing of the face, fulness in the head, vomiting, and a desire to defæcate; breathing was not much embarrassed. At 1.40 there was a chill, lasting twenty minutes. Hot bottles were ordered, and ten grains of quinine and a fourth of a grain of morphia. At the time of the operation the temperature was 99·4°, pulse 104. At 8 p.m. the temperature was 100·4°; the pulse 94 and much fuller. On June 16th he had slept well and felt stronger; temperature, 99°; pulse, 98. There was no albumen in the urine. He was stronger and walked about better. On June 20th, at 11.20 a.m., eight ounces of milk were injected into the right median basilic vein at a temperature of 100° Fahr., twenty grains of quinine having been administered previously. The injection occupied five minutes. The pulse fell from 135 to 114, and became stronger. At 1 p.m. there was a chill, lasting twenty minutes. The temperature rose to 103°. He was ordered ten grains of quinine, and soon the temperature fell. On June 21st he had an easy night, and was stronger. There was much albumen in the urine, which disappeared the following day. On June 27th six ounces of milk were injected. The usual train of symptoms followed, and a chill lasting twenty-five minutes, and, for fifteen minutes, absolute blindness. On June 28th the urine contained albumen and phosphates. Morning temperature, 102° Fahr.; evening 104° Fahr.; pulse, 120. He was ordered ten grains of salicylic acid every three hours. On June 29th he passed ten pints of urine in twenty-four hours (compare the polyuria of Moutard-Martin and Charles Richet); and the urine contained albumen. Death occurred on July 1st. A necropsy showed that the heart was flabby, and presented marked fatty degeneration. The lungs were adherent, and there were cheesy nodules in the apex of the right lung. There were no metastatic abscesses, but the

lower lobes of the lungs were congested and œdematous. Small collections of pus were found in the right elbow-joint. The suprarenal capsules were mere sacs. There was slight thickening of the connective tissue of the kidneys. The marrow of the long bones showed alterations of the kind found in medullary anæmatosis. Dr. Pepper concludes that, in "this case of progressive organic anæmia, the intravenous injection of milk did no good. After the first operation, there was temporary improvement, but, after the last, grave symptoms ensued; and it cannot be doubted that the result was hastened by the operation."

From the physiological, experimental, and clinical evidence combined, the following conclusions may be drawn.

1. The intravenous injection of a small quantity of newly drawn milk is harmless.

2. Large injections of milk are fatal, with polyuria as the chief symptom.

3. The employment of impure or stale milk is most dangerous, on the probability that septicæmia will follow the operation.

4. The operation is to be recommended in the later stages of cholera, enteric fever, phthisis, and pernicious anæmia, as a substitute for the transfusion of blood; and, in short, in all cases where transfusion of blood is indicated on nutritive grounds, but where a blood-donor cannot be procured, or where this operation is, for other reasons, impracticable.

ABSTRACT OF ADDRESS ON TRANSFUSION FOR HÆMORRHAGE IN MILITARY SURGERY.

DELIVERED AT WOOLWICH, BEFORE THE MEDICAL OFFICERS OF THE ARMY MEDICAL DEPARTMENT, OCTOBER 28, 1886.

(Reprinted from the *Lancet*, January 15, 1887.)

GENTLEMEN,—When I accepted the kind promise of Sir Thomas Crawford to arrange for my addressing you this evening, I did so to learn rather than to teach, feeling convinced that what little information I may impart on the subject of transfusion for hæmorrhage will be more than counterbalanced by what I shall learn from you as to the applicability of the operation to the exigencies of military practice. By means of demonstrating a reliable method of transfusing blood, and of proving that the simple injection into the veins of other fluids—notably saline fluid, or even water—may be safely trusted as an efficient substitute for the more complex operation, I shall be able to remove from your minds that prejudice against these therapeutic measures, which doubtless exists on account of the defective instruments, which in the past rendered the operation uncertain in its results and almost useless.

It is scarcely necessary to point out that in all cases where either transfusion of blood or intravenous injections of saline fluids is resorted to as a means of combating acute anæmia, the simultaneous or previous arrest of the hæmorrhage must be regarded as a *sine quâ non*. There seems no question that saline fluids may be substituted for blood in the human subject with impunity, such substitutions not exceeding an amount which bears a definite ratio to the body weight; but if the loss of blood by hæmorrhage has exceeded this quantity (probably about one-fifth of

the entire amount in the body) the transfusion of blood to restore and maintain reanimation becomes indispensable. The important fact remains that life may be jeopardised by hæmorrhage and successfully restored if fluid be injected into the veins *even after the heart has ceased to beat*, in illustration whereof I can refer to a series of experiments which I performed with the view of ascertaining the best plan of procuring resuscitation after chloroform and narcotic poisoning.*

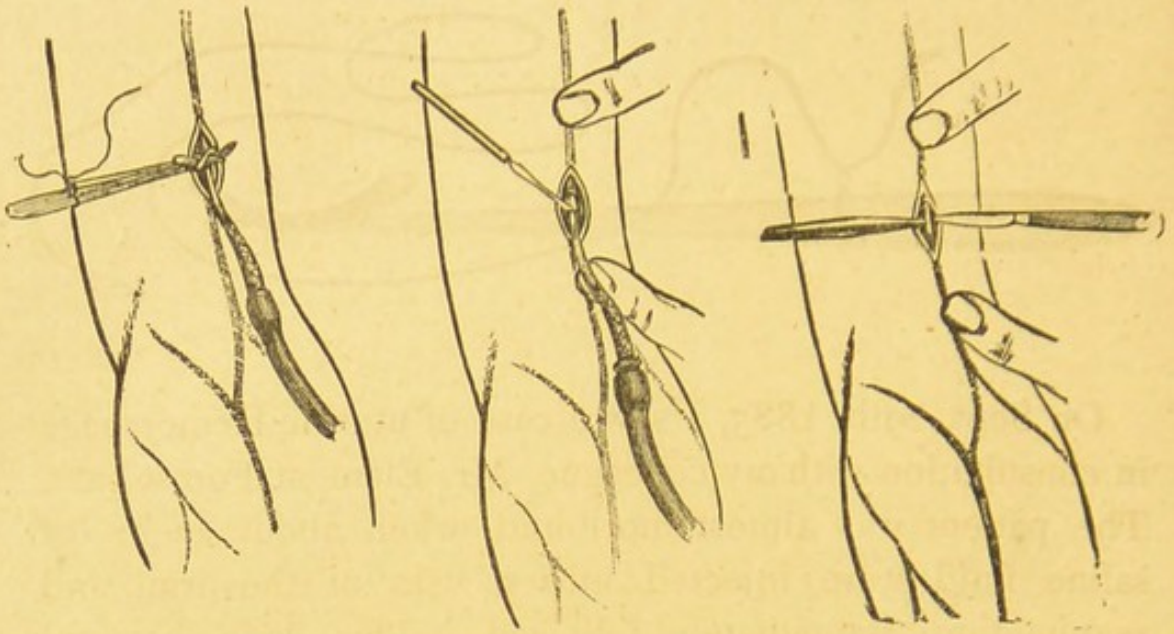
The idea of endeavouring to resuscitate animals by establishing an artificial circulation after apparent death was suggested to me by the fact that in 1848,† at the St. Giles's Workhouse, Sir Spencer Wells (then Mr. Wells) injected saline solutions into the veins of some cholera patients there, with Mr. Bennett, who was at that time resident surgeon. Sir Spencer Wells has informed me that in one case the injection was performed with considerable difficulty upon a man apparently dead some few minutes after the heart had ceased to beat, but it was followed by a return of pulsation, warmth, and consciousness, and the patient lived for a few hours afterwards.

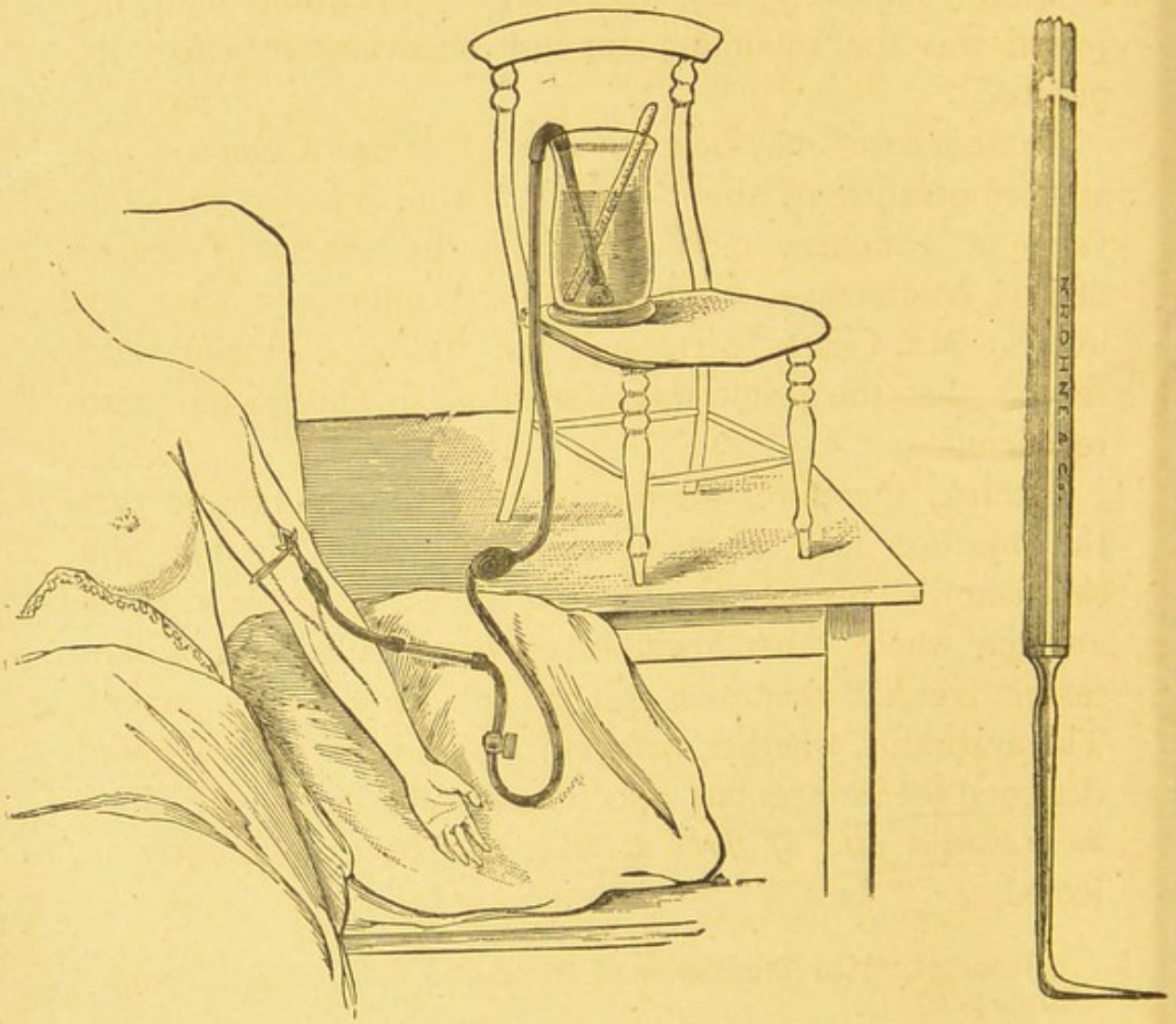
On August 20th, 1882,‡ I injected 16 oz. of saline fluid with a 3-oz. metal syringe into the veins of a patient about to die from the effects of ante-partum hæmorrhage. The cylinder of the syringe had to be detached from the nozzle and refilled several times during the procedure, the nozzle being ligatured within the median basilic vein. In this case reanimation speedily followed the saline infusion. The woman was happily delivered an hour and a half later, and recovered perfectly. The lesson here taught was that 16 oz. of saline fluid proved to be the minimum quantity necessary to restore reanimation.

* The *Lancet*, 1885, vol. i., pp. 245, 289.

† Jennings, "On Transfusion of Blood and Saline Fluids," second edition, p. 34.

‡ *Ibid.*, p. 25.

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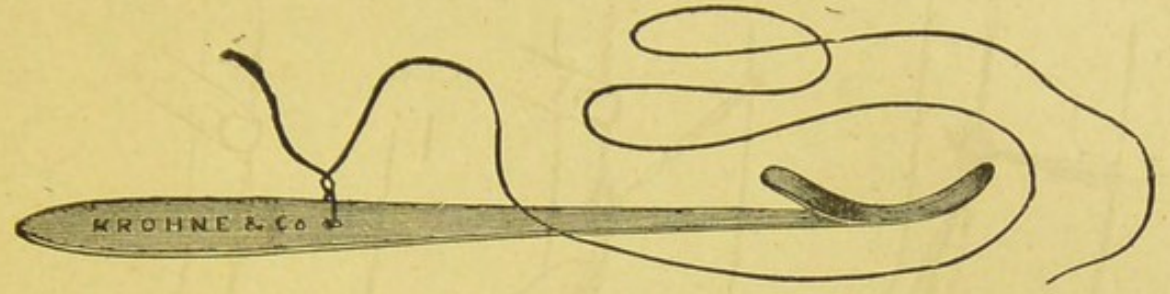


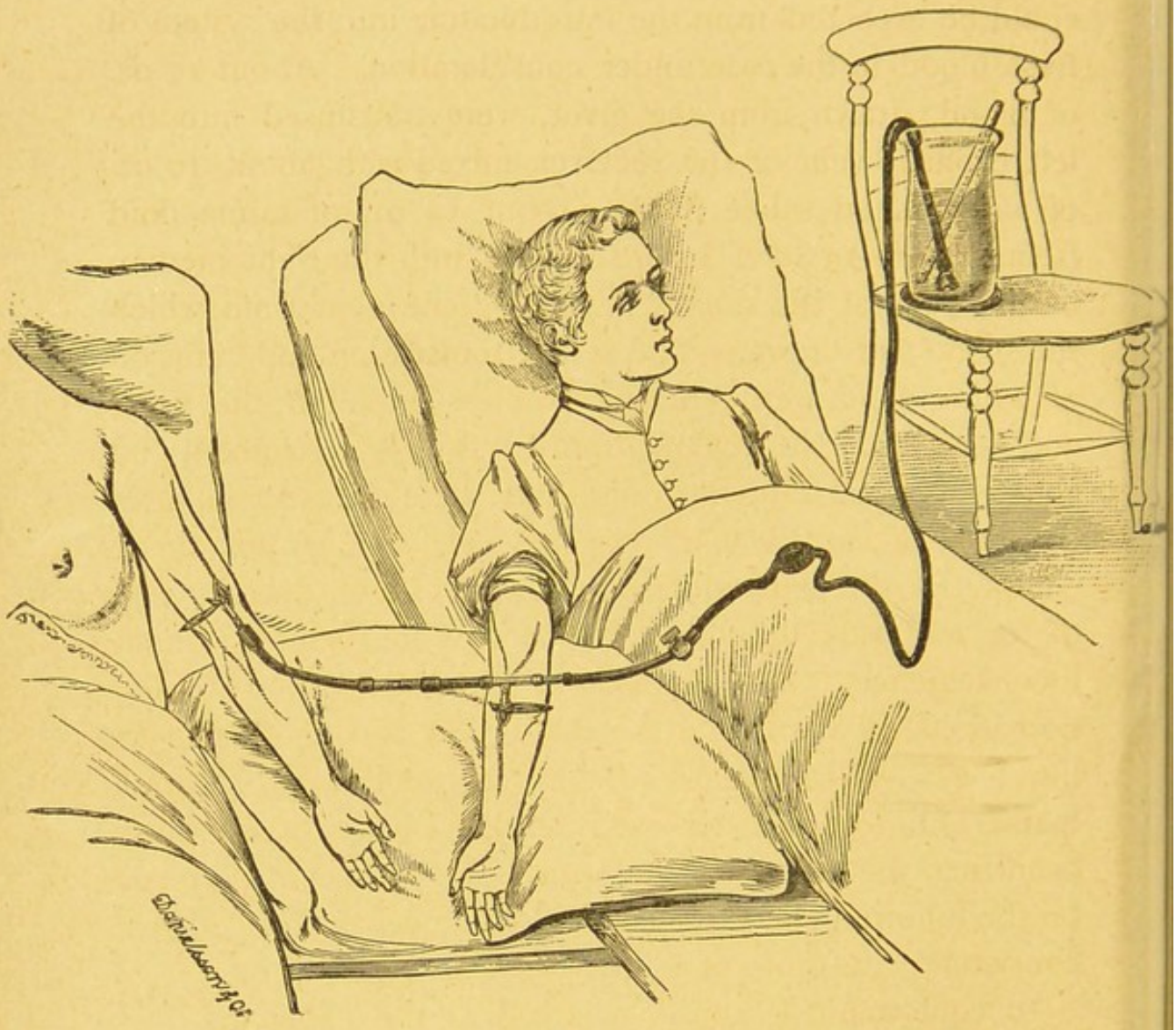
On Sept. 29th, 1885, I saw a case of uterine hæmorrhage in consultation with my colleague, Mr. Elam, at Forest gate. The patient was almost moribund, when about 22 oz. of saline fluid were injected into a vein of the arm, and reanimation immediately followed. This lady has recovered completely, and the quantity of saline fluid injected was the minimum amount necessary to effect its purpose.

Another case* may be cited where "22 oz. of *simple water* at a temperature of about 100° F." were injected into the veins of a woman moribund from the effects of severe uterine hæmorrhage, which occurred nine days after delivery. Mr. Coates performed the trifling operation, and reports that the result was marvellous. This patient also recovered.

I think, therefore, we are justified in maintaining that the injection into the veins of a fair quantity of fluid will satisfactorily restore reanimation in cases of very acute anæmia where other restoratives have failed, for potent restoratives had been tried and had failed in the cases quoted. The apparatus, whether syringe, irrigating-can, or by syphon, designed for intravenous injection, should be one by which *more than a pint of fluid* at least can be expeditiously injected.

* Jennings, "On Transfusion of Blood and Saline Fluids," second edition, p. 67.

Though a description of my method of transfusing blood mixed with saline fluid and of replenishing the veins of the blood-giver with saline fluid, with the results of experiments upon animals, which have clearly shown the safety



and utility of the method, had been published long ago, it was only in 1885 that this operation was actually performed upon the human subject.

In December, 1884, J. B——, a widower, manifested the signs and symptoms of progressive pernicious anæma. Mr. Wm. Wickham, of Tetbury, finding his patient's condition was not ameliorated by a careful trial of the various forms of

treatment ordinarily recommended, sent the patient to me at the Cancer Hospital, in the hope that benefit would accrue from the transfusion of blood. Transfusion was performed on April 17th, the patient and his friends having been previously informed that only transient improvement could be expected from the introduction into the system of fresh blood in the case under consideration. About 14 oz. of blood, drawn from the giver, were transfused into the left cephalic vein of the receiver, mixed with about 10 oz. of ammoniated saline fluid. About 14 oz. of saline fluid (temperature 75·80° F.) were infused into the right median basilic vein of the donor, this being the vein from which the blood was drawn. The actual transfusion and infusion of saline fluid were entirely painless both to the giver and receiver. No coagula formed in the instrument, no air was injected into the veins, and there were no signs of dyspnœa or cardiac embarrassment. The operation being completed, the man who gave the blood arose, drank a cup of tea, and walked home, a distance of four miles, without inconvenience. The wound in his arm healed quickly, and no bad effects attended the substitution of saline fluid for his blood. With regard to the receiver of the blood a marked improvement followed the operation ; but, a relapse occurring, the man died on April 24th. A necropsy made on the following day disclosed that the morbid changes were consistent with those of oligocythæmia rubra.

In conclusion, I would submit that the cases are rare where it becomes necessary to transfuse blood for acute anæmia, the intravenous injection of fluid being usually sufficient to restore reanimation. The value of the addition of fresh blood lies merely in its nutritive properties, and if it be considered necessary to transfuse blood, the operation can readily be performed in the manner indicated by any surgeon with the aid of skilled assistants, as in the case, already related, of pernicious anæmia.

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THE END.

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