intensely painful seizures. The causes of the obstruction are not the same in every case. It may be that the lumen of the arteriole is narrowed from disease so that under exertion some part of the heart muscle does not obtain a sufficient supply of blood and therefore an ischemia is established; or we may have a rise in blood pressure during which the coronaries participate in the general arterial contraction, but this contraction may be sufficient to obliterate the stream in one of the cardiac branches which is already narrowed by disease. It is perfectly possible that some of the attacks are due to very minute emboli or sclerosis permanently obliterating a small vessel. The rapidity with which in many instances an attack yields to vasodilators such as nitroglycerin or amyl nitrite has for many years warranted the belief that vascular spasm plays a very prominent part in the production of the pain, but the fact that general high blood pressure is present in some cases of angina pectoris, absent in others, and present in a very large number of people who never suffer from angina pectoris inclines me to the belief that spasm of the coronary arteries is the essential feature in producing the attack and that the relief that follows the administration of such substances as nitroglycerin is due to the relaxation of the coronary spasm which would take place independently of any fall in general blood pressure; in short, that in those cases in which the blood pressure is high the pain is due to overcontraction of some coronary branch and not to pressure exerted on the ventricular cavity on account of increased peripheral resistance. Such a hypothesis explains the existence of angina irrespective of high or low blood pressure; it explains those cases, sometimes described as spurious angina, in which patients have suffered from a typical seizure consequent on errors in digestion and metabolism; it explains the improvement in those patients who at one time could not walk across a room without provoking a seizure but who as a result of appropriate treatment are able to walk two or three miles without difficulty.

This local vasomotor spasm is nothing new in medicine. In Raynaud's disease we can observe it in the finger, on the body surface, or on some part where it may persist with such intensity as to terminate in multiple gangrene or pass away and leave the patient with very little evidence of the attack. Transient loss of consciousness and brief hemiplegias in the course of the disease indicate that not even the cerebral vessels are exempt from the spasmodic contraction. It is therefore perfectly possible that similar local spasm may affect the vessels of the heart.

It seems, therefore, that with our present knowledge we are warranted in believing that angina pectoris is due to some form of obstruction in the coronary circulation; that the changes in the peripheral blood pressure are coincidences rather than causes of the attack; and that the degeneration of the cardiac muscle may be the consequence of the impaired coronary supply but not the cause of the painful seizure.

The treatment of those two forms of angina will be entirely different during the seizures, but as a rule it is identical between the paroxysms. Since cardiac asthma is due to failure of the right ventricle rapidly acting stimulants, such as caffeine, camphor, or strophanthus, will be indicated for the relief of the paroxysm; while angina pectoris, on account of the coronary spasm, will call for vasodilators such as nitrite of amyl, nitroglycerin or morphin. It not infrequently

happens that the subject of coronary spasm is also suffering from a weak heart and under such circumstances a combination of heart stimulant and antispasmodic is demanded.

Between the attacks the treatment is that which has been recommended in cases of chronic myocarditis and arteriosclerosis. The regulation of diet, in regard to both variety and quantity, so that the circulation never will be overloaded with food or waste material, is of the greatest importance. Avoidance of mental and physical strain and the regulation of exercise in accordance with the capabilities of each individual case must be carefully observed. The administration of arsenic and the prolonged use of iodids in small doses for a period of several months will be found in many instances to have a very beneficial effect on both the cardiac muscle and the blood vessels. And last, we never should neglect the judicious use of remedies which will aid in eliminating by their natural channels all toxic substances resulting from physiologic activity or food metabolism.

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A NEW METHOD FOR THE TRANSFUSION OF BLOOD

AN EXPERIMENTAL STUDY *

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A method of transfusion by means of a vascular bridge, composed of a fresh animal blood vessel, interposed between the artery of the donor and the vein of the recipient, was described in a preliminary communication¹ some months ago. Since then further experiments have been carried out in order to find means of preserving ready for use the vascular bridge, which, for the sake of brevity, will be called simply the "link" throughout the rest of the paper.

It is not our purpose to discuss when and where transfusion is indicated. The future alone can show whether the present enthusiasm is justified, and whether transfusion is here to stay. That, however, direct transfusion is being quite largely practiced is readily seen by the numerous modifications of the technic constantly appearing in the literature, and by a recent discussion held at the meeting of the New York Academy of Medicine, Surgical Section, Jan. 8, 1909. Dr. Hartwell, in connection with a paper he then read² on a new method of transfusion by means of direct intubation of the artery into the vein, referred to forty-one cases of transfusion done with the aid of various cannulae (chiefly by Crile's technic) which he had collected through private communication with eighteen surgeons of New York City. In this series twenty technical failures were recorded. It has been our privilege to witness personally twelve transfusions on the human subject. In all of these the exposure of the artery proved tedious and in some cases difficult, chiefly because of numerous minute side branches which required ligation. If these branches are seen before they are cut

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1. Frank: New York Med. Jour., Nov. 28, 1908.

2. Hartwell, John A.: A Simple Method of Blood Transfusion without Cannula, THE JOURNAL A. M. A., Jan. 23, 1909, lii, 297; Am. Jour. Surg., March, 1909.

across, ligation is not difficult; if on the other hand, as not infrequently happens, they are torn, annoying bleeding occurs, to stop which it may be necessary to apply lateral ligatures on the artery, thus partly occluding its lumen, either through actual constriction or through the resulting parietal thrombus. Another difficulty is encountered in the choice of the cannula; if it is too small the vessel is constricted, if too large cuffing will prove difficult or impossible. This difficulty is to some extent prevented by the use of either the Elsberg³ or Levin⁴ instrument. Again when the final union of artery and vein is undertaken, the operator is obliged to work in a cramped space at great disadvantage. In consequence of these difficulties it requires from twenty to forty-five minutes to establish union between artery and vein, if everything goes smoothly, while double that length of time is not unusual. Such prolonged exposures necessarily produces contraction of the radial artery with consequent im-

Fig. 1.—Wire frame used to stretch the link during preservation, with cannula in position.

Fig. 2.—Crile cannula slightly modified in shape. The end is more pointed and the grooves for ligatures are farther removed from the opening. This favors easier introduction.

Fig. 3.—Link ready for use, in sealed test-tube, immersed in paraffin oil.

pairment of the flow of blood, and greatly favors clotting, especially if all the safeguards so necessary in vascular surgery are not scrupulously observed.

ADVANTAGES OF THE LINK

The use of the link offers the following advantages:

1. A sufficient length of vessel is obtained without extensive dissection of the artery of the donor or the vein of the recipient.
2. The link as now prepared by us has lost some of its elasticity and is well stretched, so as to afford an unobstructed lumen within the cannulae.
3. The technic is familiar to every surgeon from its similarity to that used in intravenous infusion.

FORMS OF LINKS

1. *Fresh Links.*—The fresh links, as first suggested, required preparation immediately before they were needed, which entailed obtaining a dog of suitable size, aseptic removal of its two carotids, etc. It was also found that unless the carotid fitted the cannula accu-

ately a considerable diminution in caliber was caused by the contraction due to the elastic tunic, which served to shorten and at the same time thicken the vessel wall, thus producing a constriction of greater or lesser degree within the cannula. All these faults are overcome by means of the following method of preparation.

2. *Formalinized Links.*—Fresh carotids are obtained from medium-sized dogs, immediately after death, carefully washed out with cold normal salt solution, and stripped of any surrounding connective tissue. The adventitia at both ends is drawn over the cut end of the artery and snipped off. A Crile, or other tube of appropriate size, is selected, the artery pushed through the tube and by means of two eye forceps cuffed and secured with a fine silk ligature tied in the groove nearest to the handle. The opposite vessel end is similarly cuffed over another Crile tube, care being taken to have the handles pointing approximately in the same direction transverse to the long axis of the link in order to avoid torsion subsequently. The completed link is now stretched and kept stretched by means of a

Fig. 4.—Schema of transfusion.

small frame readily improvised of soft brass wire (Fig. 1) which serves to keep the cannula sufficiently far apart to thin the walls of the link and thus afford a wide lumen within the cannula. The tension should not be so excessive as to flatten the link at its central portion.

All the steps just enumerated may be taken without aseptic precautions. The link, stretched on its wire frame, is now placed in a wide test-tube, containing freshly prepared formalin of 2 per cent. strength (2 c.c. of chemically pure formalin of 40 per cent., in 98 c.c. of water) and well stoppered with a thick cotton plug. After twenty-four hours, using the usual bacteriologic technic, to avoid contamination, the link is transferred into a tube of sterile normal salt solution and after one-half to one hour transferred to a similar tube for the same period. These two changes serves to remove any excess of formalin, which if left, in time renders the links brittle and useless. Finally, the link is preserved for future use in sterile paraffin oil, the end of the test-tube being sealed with a blow-pipe flame (Fig. 3). The method of preservation serves to impair the resiliency of the link sufficiently to keep the lumen well open and to increase the distance between the cannula permanently, even after the wire frame is

3. Elsberg, Charles A.: A Simple Cannula for the Direct Transfusion of Blood. *THE JOURNAL A. M. A.*, March 13, 1909, III, 887.
4. Levin: *New York Med. Jour.*, Oct. 3, 1908.

removed. The optimum time in formalin has been found to be twenty-four hours, but fairly effective links were obtained up to forty-eight hours. Links used direct from the formalin, or from the salt solution produces no clotting, showing that the paraffin oil is not essential. This fluid was chosen because it helps to soften the tissues, is bland, and later proves useful at the transfusion. Links kept by this method for ninety days were pliable and as elastic as thin rubber tubing.⁵

3. *Dried Links*.—We have lately tried another method of preserving the links, suggested by Dr. Carrel.⁶ As applied to our work the steps enumerated in obtaining and preparing the links are the same as those previously described up to that of the placing them in the formalin solution, except that the fresh link should not be as tightly stretched. Instead of being placed in

the cannula, as is the case with freshly obtained vessels.

4. *Glass Tubes*.—Before describing the application of the links, it may prove of interest to mention that during the course of the experiments we attempted to use glass tubes, carefully coated inside and out with hard paraffin. In only one instance out of five did clotting fail to occur within twelve to seventeen minutes. Dr. Alexis Carrel, in a private communication, informed us that he also found glass tubes unreliable for the same reason.

The appended summary of experiments shows that of twenty-six transfusions performed with prepared links, but one failed. In this instance (experiment 15) the link had been kinked during preparation and therefore did not permit the blood to pass through at all.⁷ It is now our custom to test the permeability of the link before using, by means of a small syringe filled with salt

EXPERIMENTS IN USE OF VASCULAR LINK FOR TRANSFUSION OF BLOOD

Experiment.	Method of Preparation of Link.	Days Kept.	Duration of Transfusion. Min.	Results and Remarks.
1	Fresh.	0	45	Good.
2	Fresh.	0	45	Good.
3	Fresh.	0	45	Good.
4	Fresh.	0	45	Good.
5	Fresh.	0	30	Good.
6	Fresh. Kept at 33 C. in NaCl solution.	10	45	Good.
7	Fresh. Kept at 33 C. in NaCl solution.	7	45	Good.
8	Fresh. Kept in paraffin oil at room temperature.	14	25	Good.
9	Fresh. Kept in paraffin oil at room temperature.	14	25	Good.
10	Fresh rabbit's aorta used on dog.	0	60	Good.
11	In 2 per cent. formalin ½ hour. Kept in oil.	3	60	Good.
12	In 2 per cent. formalin ½ hour. Kept in oil.	7	35	Good.
13	In 2 per cent. formalin 2½ hours. Kept in oil.	11	35	Good.
14	In 2 per cent. formalin 24 hours. Kept in oil.	60	35	Good.
15	In 2 per cent. formalin 48 hours. Kept in oil.	20	..	Lumen not patent.
16	In 2 per cent. formalin 36 hours. Kept in oil.	20	30	Good.
17	In 2 per cent. formalin 36 hours. Kept in oil.	20	35	Good.
18	In 2 per cent. formalin 48 hours. Kept in oil.	60	35	Good.
19	In 2 per cent. formalin 48 hours. Kept in oil.	12	30	Good.
20	In 2 per cent. formalin 24 hours; 2 changes of NaCl solution. Kept in oil.	19	30	Good.
21	In 2 per cent. formalin 24 hours; 2 changes of NaCl solution. Kept in oil.	19	30	Good.
22	In 2 per cent. formalin 24 hours; 2 changes of NaCl solution. Kept in oil.	19	30	Good.
23	In 2 per cent. formalin 24 hours; 2 changes of NaCl solution. Kept in oil.	23	30	Good.
24	In 2 per cent. formalin 24 hours; 2 changes of NaCl solution. Kept in oil.	90	30	Good.
25	In 2 per cent. formalin 48 hours; 2 changes of NaCl solution. Kept in NaCl sol.	15	30	Good.
26	In 2 per cent. formalin 2½ hours; 2 changes of NaCl solution. Kept in NaCl sol.	14	20	Good.
27	In 2 per cent. formalin 48 hours. Kept in NaCl.	14	35	Good.
28	In 4 per cent. formalin 48 hours. Kept in oil.	5	35	Good.
29	In 4 per cent. formalin 19 days; used direct from formalin.	19	15	Clotted after 15 minutes.
30	In 2 per cent. formalin 10 days; used direct from formalin.	10	30	Good.
31	In 2 per cent. formalin 48 hours. Kept in oil.	12	30	Good. Tied off, no clotting.
32	Dried 24 hours, heated 12 minutes at 100 C. Kept sealed.	5	40	Good.
33	Dried 48 hours, heated 15 minutes at 100 C. Kept sealed.	5	30	Good.
34	Dried 48 hours, heated 15 minutes at 105 C. Kept sealed.	3	30	Good.
35	Dried 48 hours, heated 15 minutes at 105 C. Kept sealed.	60	30	Good.
36	Dried 48 hours, heated 15 minutes at 105 C. Kept sealed.	60	30	Good. Cat's carotid used on dog.
37	Dried 24 hours, heated 12 minutes at 105 C. Kept sealed.	5	30	Good. Tied off, no clotting.
38	Glass tube coated with paraffin oil.			Clotted in 5 minutes.
39	Glass tube coated with hard paraffin inside and out.		20	Ran fairly well.
40	Glass tube coated with hard paraffin inside and out.			Clotted in 17 minutes; ran poorly after 5 minutes.
41	Glass tube coated with hard paraffin inside and out.			Clotted in 15 minutes; ran poorly after 5 minutes.
42	Glass tube coated with hard paraffin inside and out.			Clotted in 15 minutes; ran poorly after 10 minutes.
43	Dog's carotid, formalin 2 per cent. for 2 hours; oil 10 days; in Arnold steam sterilizer 30 minutes.			Lumen not patent, shrunken and distorted.

formalin the link is dried for twenty-four to forty-eight hours over fresh anhydrous calcium chlorid in the ordinary chemical drying chamber. By this time it looks dry, shriveled and brittle as parchment. It is now placed in a sterile test-tube and heated for twelve to fifteen minutes at 100 to 105 C in the dry sterilizer. The tube is then sealed. About an hour and a half before the dried link is to be used it is placed in sterile salt solution or Lock's fluid. At the expiration of that time it will have regained its normal appearance and elasticity. This method has proved excellent and has but one drawback, namely, that the great elasticity of the vessel serves partially to occlude the lumen inside

solution, in order to assure ourselves that the lumen is unobstructed and in order to wash out the paraffin oil. To favor clotting, the blood current was repeatedly interrupted. In two experiments, links inserted in the carotid artery were tied off and the blood allowed to remain within the lumen of the link for fifteen and thirty minutes without resulting thrombus formation.

TECHNIC OF TRANSFUSION BY THE USE OF VASCULAR LINKS

About one inch of the artery of the donor, in man the radial, is exposed under local infiltration anesthesia without the use of adrenalin, no great care being exercised in freeing the vessel from its sheath. Two

5. It has been found necessary to have both the cannulae of the wire frame gold-plated (silver-plated might do as well), as an electrolytic reaction is set up, if two different metals are used, which causes a deposit of copper on the surface of the link, thus favoring clotting.

6. Carrel: Proc. Phil. Soc. Philadelphia, Nov. 6, 1908.

7. An attempt to sterilize a link in the Arnold sterilizer proved a failure. In one experiment in which the link was kept for nineteen days in 4 per cent. formalin and used direct from this, clotting occurred.

ligatures are passed around the artery, the distal one being applied as far peripheral as possible and tied, the proximal left loose. A vein of fair size in the recipient is similarly exposed (in infants the femoral must be used), and the ligatures passed, the distal one again being tied. On both artery and vein a *serre-fine* is applied proximal to the loose ligature in order to stop the circulation temporarily.

The link is emptied of the paraffin oil and placed in salt solution to be ready for use. The artery is pulled out of the wound by means of the ligature and with a snip of the scissors a small transverse slit is made into its lumen. The edges of the slit are grasped on either side with two fine eye forceps and drawn apart. Through this aperture the one end of the cuffed link is introduced toward the heart (the handle of the cannula being steadied with an artery forceps) and the loose ligature tied in the first groove of the cannula. The vein is treated similarly, the opposite end of the link being inserted toward the heart, and the ligature tied. (It is well to make the slit in the vein near the distal angle of the skin wound in order to have a portion of the vein visible and palpable, as this enables the operator to see and feel the pulsation and thus control the transfusion, or at once to recognize a stoppage of the flow.) The *serre-fines* are now removed, the one on the vein first, and the exchange of blood allowed to proceed (Fig. 4). Throughout the manipulation both wounds should be kept well moistened with salt solution. During the transfusion the link should be supported by a gauze sponge saturated in salt solution and covered by another moist compress.

When enough blood has been obtained both artery and vein are tied off, the small injured part of the vessels being excised. The skin wound is then closed.

This technic closely resembles that so familiar in intravenous saline infusion, the infusion cannula being represented by the cuffed link. Should the opening in the artery prove too small, a very fine blunt artery forceps or scissors may be inserted closed, and then opened in order to stretch the lumen.

For adults, carotids obtained from medium-sized dogs should prove the proper size, as they are easily cuffed on the large or medium Crile tube. If a smaller cannula is desired, a cat's carotid is available, though of course much shorter in length. The stretched dog's vessel is three and one-half to four inches in length, the cat's half that. The hypothesis that clotting is due to an alien blood vessel has been disproved by the work of numerous investigators. We also have used rabbits' and cats' vessels on dogs with complete success.

TESTS OF THE STERILITY OF PREPARED LINKS

A series of links were prepared, without aseptic precautions and immersed for two to eight hours in 2 per cent. and 4 per cent. formalin. This entire series proved sterile. A similar series of links were infected with the spore-bearing *Bacillus anthracoides*, incubated for forty-eight hours, immersed for one to thirty-six hours in 2 per cent. formalin and then tested after thorough removal of the formalin. No growth took place in the tubes subjected to formalin for more than ten hours. Numerous control experiments showed abundant growth.

SUMMARY

1. The links are prepared by cuffing dog's carotids at both ends over Crile's tubes, stretching them on a wire frame and fixing them for twenty-four hours in

2 per cent formalin. The formalin is removed by two changes of sterile salt solution (thirty to sixty minutes each), and the links permanently preserved in sterile paraffin oil.

2. Of twenty-six transfusions performed by means of prepared links, but one failed (owing to kinking of the vessel during its preservation).

3. The method of preservation kills bacteria, including spore-bearers.

4. The technic if transfusion corresponds closely to that used in intravenous saline infusions.

As far as can be predicted, the use of the prepared links affords a simpler and easier method than those hitherto described, and it is hoped that it will soon receive trial on the human subject.⁸

In conclusion we desire to express our obligations to Dr. T. Mitchell Prudden for extending to us the courtesies of the laboratory, to Dr. Carrel for his kindness in permitting us to use his method of preparing vessels before he had published it, to Dr. H. Zinzer for supplying us with test cultures, and to Dr. Simons for assistance in the bacteriologic tests.

983 Park Ave.

THE INCUNABULA IN THE SENN COLLECTION AT THE JOHN CRERAR LIBRARY *

AKSEL G. S. JOSEPHSON

Cataloguer, the John Crerar Library
CHICAGO

The most interesting part of the Senn collection is undoubtedly the library of Professor Wilhelm Baum, of Göttingen, which Dr. Senn purchased at auction in 1885. Professor Baum was one of the most learned surgeons of his time and exercised a wide influence on succeeding generations of students and physicians, both as a teacher and practical surgeon, although he wrote practically nothing after receiving his degree in 1822. From 1829 to 1842 he was the head of the city hospital in Dantzig, and from 1842 to 1875 held positions as professor of surgery, first at Greifswald, afterward at Göttingen. After his retirement in 1875 he spent his leisure in collecting material for a history of surgery, though he never came so far as to write any part of it. Dr. Baum was a book collector all his life, and he placed his library most generously at the disposal of other students; it is a working scholar's library, not a bibliophile's; there are no tall copies in it, no books printed

8. Through the kindness of Dr. A. V. Moschcowitz we have recently had the opportunity of performing a transfusion on a human being by our method. Technically the operation was as simple as when performed on animals. The blood ran freely for six minutes and then ceased to flow. During this short time the hemoglobin rose from below 10 per cent. on the Sahli scale to 20 per cent.; next day it was found to be 27 per cent.

From this single trial we have learned that the method proposed is as devoid of danger as other methods. We have found that a cannula corresponding to the outside diameter of the radial artery is readily introduced into this elastic vessel, and that the link may be advantageously reduced to a length of two or two and a half inches.

The stoppage of the flow was due to a small clot at the venous end of the link, within the vein; for when the cannula was withdrawn from the vein, the blood spurted freely through the link. The only partial success of the trial was, in our opinion, due to the deposit of a copper salt on the surface of the link. This may be avoided (as mentioned in Note 5) by using cannulae and wire frame both gold-plated.

* Read at a regular meeting of the staff of the John Crerar Library, March 24, 1909; also at the annual meeting of the Chicago Chapter of the Bibliographical Society of America, April 29, 1909. The historical data in this paper have been taken chiefly from Puschmann's "Handbuch der Geschichte der Medizin," Gurlt's "Geschichte der Chirurgie," and Sudhoff's "Tradition und Naturbetrachtung in den Illustrationen medizinischer Handschriften und Frühdrucke."