THE ARTIFICIAL ANASTOMOSIS BETWEEN THE PORTAL VEIN AND THE VENA CAVA INFERIOR—
ECK'S FISTULA.¹

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PLATES VI-VIII.

It is the purpose of the following paper to discuss briefly the methods which have been used in the operation for directing the blood of the portal vein into the vena cava, and to describe a new instrument for cutting the opening between the veins. The operation is named after N. V. Eck (1), who conceived the idea of establishing an artificial anastomosis between the portal vein and the vena cava, in order to relieve the congestion of the portal system in cirrhosis of the liver. Never attempted upon the human being, the operation performed on dogs has yielded a great part of the experimental facts concerning the normal physiology of the liver, and still offers an invaluable method for approaching many problems of metabolism. I shall leave aside for the present the question of the changes in the animal economy which follow the diversion of the portal blood current, simply appending a list of the literature bearing upon the subject.

The necessity of a stringent asepsis during a surgical procedure requiring between one and two hours for its completion is self-evident. The unusual difficulties encountered are peculiar to this operation and are purely of a mechanical nature: one is referable to the inaccessibility of the site of the operation—that portion of the portal vein extending about five to eight centimeters below the opening of the vena pancreatico-duodenalis, and the somewhat longer section of the vena cava between the

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hepatic and the renal veins; another is due to the extreme thinness and delicacy of the walls of the portal vein; but the chief difficulty is that of cutting an opening in the coapted walls of the two vessels within an oblong space bounded, except at one or two points, by a row of firmly tied sutures.

All who have successfully performed the operation have followed essentially the same technique up to the cutting of the fistula opening, except in the method devised by Queirolo (6) and later modified by von Karltreu (18, 22). Queirolo's operation has already been sufficiently criticised (7); von Karltreu's modification may correct the fault of Queirolo's method, but the distortion of the channels through which the blood must pass, and the traction upon the vena pancreatico-duodenalis are manifest disadvantages, and the operative results obtained by von Karltreu indicate that they are more than mere disadvantages. The question of the fact of the distance between the vena pancreatico-duodenalis and the first branchings of the portal vein into the liver² is one which every one can settle for himself. In my own experience it depends entirely upon the dog. The method described by Tansini (23) has not received the impress of experimental results; I do not believe it possible, because of the inaccessibility of the site of the operation.

The details of my operation are as follows. A dog—the size is immaterial—is anæsthetized by a mixture of one part chloroform to four parts ether; the abdomen is shaved and scrubbed and washed with 4 % carbolic acid; the dog and the operating table are then entirely covered with sterilized towels, the towel covering the dog's abdomen being made to adhere slightly by dampening with sterile salt solution. Towels, instruments, suture material, etc., are sterilized in the autoclave. An incision of sufficient length is then made in the median line, and the field of operation exposed by an assistant who holds the intestines toward the splenic side of the peritoneal cavity. The first step is the placing of the ligature around the portal vein below its first branchings into the liver and above the opening of the vena pancreatico-duodenalis, the tying of which, immediately

² See von Karltreu (22), p. 63.

after the fistula opening has been made, will constitute the final step in the operation. The portal vein is then freed of the sub-peritoneal fat, if it be not already free for a sufficient extent, by blunt dissection.

An oval of the desired size, about three centimeters long by six to ten millimeters wide, is then mentally planned and a row of sutures is laid along the side of this oval nearer the spleen (Fig. 1). The sutures should be about three or four millimeters apart. The delicacy of the wall of the portal vein makes it necessary to pass the needles each time into the lumen of the vessel, a procedure which makes it essential that the needles be of extremely small size, and that the silk be of such nature as to fill completely the hole.

The needles which we have used are fashioned from the smallest size (No. 15) of round needle found on the market for use in bead work. They are made with a long eye, which greatly facilitates threading. The temper is drawn, the needles are cut to about two thirds their original length, sharpened to a very fine, round point, bent to a half curve, and then re-tempered. The needle-holder used is a Halstead mosquito hæmostat. The needles carry a fine, loose silk thread obtained by untwisting the two strands of the finest black embroidery silk; the resultant thread is composed of many filaments of silk, but is not twisted; used double, it fills completely the holes left by the needles; the needles are, however, so fine that the wall of the portal may be punctured by them with impunity. The wall of the vena cava is of such thickness that no difficulty is experienced even with larger needles. It is found most convenient to place all the sutures along one side of the oval before tying any of them, the two ends of each suture being caught with a hæmostat to prevent an entanglement of the various threads; after all are placed, the sutures are tied, the vessels being readily brought together by the act of tying the sutures.

The next step is to place in position in each vein the silk threads by means of which the cautery wire is later to be drawn into place (Fig. 1). The cautery wire consists of a fine platinum wire, made pliable by annealing, and provided with an eye at

each end. Long silk threads of the same size as those used for the sutures are passed through each eye, and both ends of each thread then passed through the eye of a long, slightly curved needle. These needles must, because of their length, be larger than those used for placing the sutures, and the silk thread which they carry must be correspondingly thicker than that used for the sutures, in order to fill completely the holes made by the needles in the vessels. This is attained by passing both ends of the threads in the cautery wire through the eyes of the needles, and drawing them through for a sufficient distance to allow the needles, with the four-ply thread, to be drawn into and out of the vessels far enough to be out of the way of the subsequent steps (Figs. 2 and 3). One needle is inserted into the lumen of the portal vein at a point two or three millimeters below the end of the oval nearer the liver, and brought out of the portal at a point the same distance from the lower end of the oval; the other needle is introduced in the same manner into the vena cava (Fig. 1).

The oval is now completed by placing another series of sutures (Fig. 2), which are not tied until the next step in the operation—the drawing of the cautery wire into position by traction on the silk threads (Fig. 3)—has been performed. Since the cautery wire is of smaller diameter than the silk threads, some slight bleeding may occur at this time, but it soon stops, either by coagulation or after the next step in the operation—the tying of the sutures just laid (Fig. 4). The bleeding may be prevented entirely by tying the second series of sutures, except the one at either end of the oval, before drawing the cautery wire into place. We have usually, however, disregarded this hæmorrhage, which is rarely more than a mere oozing of blood, for the sake of having the assurance that the cautery wire is in its proper position. After tying the sutures of the second row, a suture is laid around the cautery wires (Figs. 3, 4, and 5) to close completely the lower end of the oval after cutting the opening. The threads are cut from the cautery wires, and the two ends of the wire threaded into the cautery (Fig. 5). The current is regulated by a simple water rheostat, which is set before the

operation so that a platinum wire of the same size as the cautery wire is heated white-hot; it is usually found necessary to increase the strength of the current, which is done by an assistant, until the operator feels the yielding of the tissue due to the cutting by the cautery. As soon as the cautery wire frees itself from the tissues, the current is turned off, the cautery is removed, and the suture at the lower end of the oval is tied. The ligature laid around the portal as the first step in the operation is now tied; the operation is complete.

The abdominal wound is closed by a row of interrupted sutures through the *linea alba* and the peritoneum, and by interrupted sutures or a continuous suture of the skin. The wound is dressed with iodoform or bismuth-formic-iodide and covered with gauze dressing pads. The dog is then tightly bandaged, the bandage being covered with a muslin shirt—a piece of muslin of sufficient length to extend from the neck to the hind legs, provided with two holes through which the fore legs are passed, the ends being cut into narrow strips, which are tied along the middle of the dog's back. This bandage is left in place for a week or ten days. Bitches are chosen for the operation, because the male dog cannot be prevented from soiling the bandage with urine, and thus infecting the wound.

I mention these minor details because Pawlow writes as follows³: "A misfortune which has often occurred has pursued us during the whole course of our operations: six to seven days after a successful operation the edges of the wound separated. If this occurred during the night we usually found our animals dead in the morning. Sometimes we could help ourselves by immediately sewing the abdomen together again. It is to be hoped that later workers succeed in avoiding this truly annoying mishap by the use of another method of suturing."

I have not had such a misfortune in my short experience with the operation; indeed, the wounds have healed in nearly every case without even a stitch abscess. I have thought this result due to the use of a tight bandage rather than to the method of suturing.

³ 3 (2), p. 167.

The construction of the cautery is shown in the diagram (Fig. 6). Two small German silver tubes (Fig. 6, a-b, a-b), insulated from each other, through which the cautery wire will easily pass, are soldered to insulated wires (Fig. 6, c, c). The insulation of the German silver tubes and the conducting wires is best accomplished by making the cautery of vulcanized fibre—the only material in our hands which has successfully withstood the heat transmitted from the platinum wire. The free ends of the cautery wire naturally remain cold; one end is held by the hand which holds the cautery in position, while traction with the other hand on the other end of the cautery wire draws the white-hot wire through the walls of the veins.

I believe that the use of the electro-cautery offers several distinct advantages over the best instrument hitherto used—Pawlow's modification of Eck's scissors. The points of these small scissors are soldered to long silver wires, the ends of which are soldered to curved needles. In regard to these scissors Pawlow himself says: "A certain number of animals succumbed because the walls of the veins were torn with the needles or with the wire ends of the scissors. Sometimes the operation did not succeed if the ends freed themselves from the blades of the scissors after the upper row⁴ of sutures was already placed. In general the faulty cohesion of the soldered joint between the silver thread and the scissors is the weak side of our instrument, and it is only to be wished that one could find a better method of soldering, as well for the result of the operation as for the operator's peace of mind."⁵

In addition to avoiding this difficulty in the construction of Pawlow's scissors—which has been obviated, at least to a certain extent, by Italian workers, who substituted a copper wire for the silver wire—I believe the method above described offers at least two very distinct advantages. By the use of the soft silk threads in placing the cutting instrument in position, the danger of cutting the veins by a wire of any kind, during the considerable manipulation necessary for the placing of the second row of sutures, is entirely avoided. In the second place, the fact

⁴ The second row.

⁵ Loc. cit., p. 167.

that the cutting instrument—the cautery wire—can be placed in actual position for cutting before the second row of sutures is tied permits the assurance that everything is in its proper position, and also makes it possible to tie all the sutures at the upper end of the oval before cutting the fistula opening. In Pawlow's method openings of sufficient size to permit the passage of the scissors must be left at both ends of the oval—openings through which a very considerable hæmorrhage may occur before the sutures placed ready for tying can be knotted. ("In the majority of cases the hæmorrhage is rather considerable, maximum sixty ccm." ⁶)

The use of the cautery makes it possible to close the upper end of the oval entirely, while the nose of the cautery occludes the lower end. The maximum hæmorrhage in our experience was about ten cubic centimeters, while ordinarily no hæmorrhage at all occurred. A further distinct advantage is that the cautery wire is so pliable that it can be introduced no matter how small the space is between the liver and the oval described by the sutures; while in Pawlow's method a space equivalent to the length of the scissors must be left between the lowest point of the liver and the highest point of the oval, since, whether the scissors be introduced from above or from below, they cannot be introduced or removed on a curve. The free portions of the veins are so limited, especially in small dogs, that any increase of available space is very welcome.

The question of the influence of the heat of the cautery upon the coagulation of the blood and the consequent formation of a thrombus in the fistula opening is one that I can answer only by referring to the results of my operations. The first six animals upon which the operation was performed, after the method described above was perfected, recovered perfectly and were utilized for further studies. Some of the results obtained have already been reported by Dr. P. B. Hawk, of the University of Pennsylvania (24).

The seventh dog, operated upon by Dr. H. J. Nichols, of Washington, D. C., at that time a fourth-year student in the

⁶ Loc. cit., p. 166.

University of Pennsylvania, recovered satisfactorily from the operation, but died three or four days later from an infection with an anaërobic, capsulated bacillus. Our operating-room had become infected with this micro-organism, and we lost six or seven other dogs from which the pancreas had been removed, from the same infection. An animal upon which I recently operated died during the following night for some reason which the autopsy did not satisfactorily reveal; the lungs showed extensive infiltration, but it was not determined whether the infiltration was to be ascribed to pneumonia or to embolism. The organs of the portal system showed no evidences of congestion. It is fair to state that the animal was in very poor condition before the operation was performed.

A ninth dog, recently operated upon, has recovered satisfactorily from the operation, making in a total of nine dogs, seven successful operations, one death from infection, and one death from what may have been the effects of the narcosis.

The work described above was performed at the Laboratory of Hygiene of the University of Pennsylvania, to the Director of which, Professor Abbott, I am indebted for every aid he could possibly extend me. I am further greatly indebted to my friend, Dr. C. R. Turner, Professor of Prosthetic Dentistry at the University of Pennsylvania, to whose patient teaching I owe the necessary knowledge of the working of metals. I would also express my thanks to Drs. Stewart, Hawk, Fager, Lewis, and Nichols, who acted as anæsthetists and assistants during the operations.

DESCRIPTION OF PLATES.

PLATE VI.

Fig. 1.—First row of sutures tied. Silk thread in place with which cautery wire is to be drawn into position.

Fig. 2.—Second row of sutures in position.

PLATE VII.

Fig. 3.—Cautery wire drawn into place.

Fig. 4.—Second row of sutures tied, except the safety suture around the cautery wire.

PLATE VIII

Fig. 5.—Cautery wire threaded into cautery.

Fig. 6.—Construction of cautery. a-b, a-b, German silver tubes. c, c, wires insulated from each other.

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