

III. TECHNIQUE OF BLOOD VESSEL SUTURE.

BY J. EDWIN SWEET, M.D.,

OF PHILADELPHIA.

IF we will remember for a moment that the first suggestion of repairing wounded blood vessels, as well as the first attempt to carry out the suggestion, dates from the year 1759,—when Hallowel, an English surgeon, at the suggestion of his fellow, Lambert, attempted to repair a wounded brachial artery, and perhaps succeeded,—it is not surprising that many have endeavored, experimentally and clinically, to elaborate a successful technique for the suture of blood vessels.

Longitudinal wounds of blood vessels, and transverse wounds involving only a portion of the circumference, are easily repaired, the technique of such procedure being the common property of all surgeons of experience. The question before us to-night is the technique of the repair of wounds which completely divide the vessel,—the question of the end-to-end anastomosis of blood vessels; a question involving accident cases, the treatment of aneurisms, the transfusion of blood from one human being to another, and, possibly, the transplantation of organs.

A most superficial consideration of the tubular structure known as a blood vessel leads to the conclusion that such a tube may be reunited in one of four ways,—I mean from the mechanical standpoint; 1. the ends may be brought as nearly as possible into their original position, approximating the various coats of the vessel to each other; 2. the edges may be everted, turning the cut edges outward; 3. one end may be inserted into the other end, invagination; 4. a mechanical aid may be employed

I am personally inclined to the belief that the method of exact end-to-end approximation,—the method which has given such remarkable results in the hands of Carrel and Watts,—is easier of execution, and since it accomplishes that great

surgical desideratum, the restoration of tissues as nearly as possible to their original position, is perhaps theoretically correct.

There seems to be unity of opinion as to the choice of suture material,—fine silk, of a size carefully chosen so that it will completely fill the hole left by the needle. The needles should be of the smallest possible size, round, either straight or curved, according to the individual and the site of operation. Experimenters are further agreed that the stitches should include all the coats of the vessel, since the penetration of the intima is a matter of no consequence.

The actual technique is, then, as follows: the exposed vessel is clamped by some means which must be very gentle, the simplest and best clamp being, in my opinion, the one devised by Herrick. The loose connective tissue of the external coat of the vessel must then be dissected away, the best procedure being to draw it down over the cut end of the vessel and to snip it off even with the vessel end; it will then retract, leaving the vessel free. This must be done, else the loose tissue will interfere by being dragged with the suture into the needle holes. All insult to the vessel wall, such as grasping it with forceps, must be religiously avoided. If the edges of the wound have been crushed they should be freshened by resecting a bit with a very sharp scalpel; since the cut of scissors is always a crushing cut they should not be used.

Three tension sutures of fine silk, impregnated with vaseline, are then laid at equidistant points of the circumferences of the vessel ends. An assistant then applies traction to two of these guide sutures in turn, stretching the portion between the two sutures into a straight line, facilitating the laying of the continuous suture, and preventing a narrowing of the lumen. If at this time the third tension suture is weighted by means of a hemostat the circumference of the vessel will be arranged in the form of a triangle, the points of which are determined by the three traction sutures, and there will be no danger of catching the opposite wall while laying the suture. The suture is a continuous, overhand stitch,

through all the coats; the separate stitches should be drawn just tightly enough to secure absolute approximation, but not too tightly else the tissues be everted; they must be laid very close together. After the completion of the suture and the removal of the clamps there will often be some hemorrhage; if this is too free a few interrupted stitches may be laid, but a considerable hemorrhage will almost always stop under gentle digital compression. I wish to emphasize this fact, because of its bearing upon the later theoretical discussion. The danger of aneurism formation is very small; secondary hemorrhage is also as rare.

Now this sounds very easy, and, in truth, it is not very difficult, except for the extreme delicacy of the needles and the silk, and of the vessel walls; it is unusual surgery, since it partakes of the art of the watch-maker. Why, then, cannot everybody succeed in performing these simple, though delicate operations? Why do we read reports varying between absolute failure and uniform success? Why, out of four operations on the neck of the same animal, do we sometimes find the arteries perfect, the veins thrombosed, or the veins patulous and the arteries closed, or only one success, or all failure, or all success? This is the question which, I think, leads us far away, into the fields where fact and theory too often establish a *circulus viciosus*.

In the first place, every author since Jassinowsky, whose work formed the first real contribution to our knowledge of this subject, has emphasized the necessity of a perfect aseptic technique. Carrel goes so far as to express his opinion that under ordinary "aseptic" conditions there are always a few bacteria which gain entrance to the wound; now these are so few that under ordinary conditions the tissues are able to destroy them. Not so in blood vessel surgery,—here we must have "absolute asepsis."

That infection around an uninjured blood vessel will cause thrombosis is banal. But I cannot believe that infection is the cause of the frequent thrombosis after blood vessel suture for several reasons; first, we find thrombosis with none of the

usual macroscopic signs of infection, and, secondly, an early examination will show small non-occluding thrombi, and older specimens will show such thrombi completely healed over. In the third place, I have often observed that a thrombus will form in a sutured vessel, especially a vein, within a few moments after the clamps are removed, certainly hours too soon for these few bacteria to have caused it. Further, if this thrombus be removed by gently "milking" the vessel, another thrombus will replace it. In other words, the causes of thrombosis lie nearer at hand than bacterial action.

Just what happens when a blood vessel is wounded? The final processes of repair have been studied sufficiently to enable us to say that the vessel wall is completely repaired. The wound of the interior is covered with proliferated endothelium; some elastic fibres may regenerate, though the elastica is possibly not as perfectly repaired as are the other coats; the external coats are reconstructed by that excess of reaction so common in Nature as to be universal, and the vessel wall becomes stronger at that point than it was before the injury.

The problem of the coagulation of the blood is an extremely complex one. We know various factors in the process; we know that foreign bodies and roughenings of the intima favor coagulation; that an interference with the free current of the blood is a favoring factor. We know that the tissues contain a substance or substances which cause rapid coagulation of the blood plasma, and that these substances are present in the tissues of the vessel wall. The formed constituents of the blood also contain these same or analogous substances. Calcium salts are necessary for the formation of fibrin. Experiments upon the vessels of animals whose blood had been made incoagulable by injections of hirudin or of peptone have shown that another process enters into the play, an agglutination of the blood plaques or platelets.

It is not necessary for us to decide between the theories concerning what happens first, or what happens further, as whether the action is a ferment action or whether it is not.

Let us think of the action of some of the factors in coagulation which I have mentioned. The suture, being inelastic, must offer a point where the current of the blood is more or less influenced; the sutures are the foreign bodies; the holes in the intima are rough; the tissue coagulins contained in the vessel wall have access to the blood through the needle holes; blood platelets are deposited in the wounds of the intima, even in incoagulable blood, and we know that a true coagulum can start from such a deposition of platelets. Further, if two factors are united in these biological phenomena, the result is usually much greater than the sum of the separate action of each factor.

That some coagulation occurs in every case seems to me to be proven by the statement to be found in every report of extensive work,—that slight hemorrhage is to be controlled by gentle digital compression. Such a method could only stop hemorrhage, it seems to me, by favoring the filling of the needle holes with a coagulum.

I therefore think that those who report uniformly successful results have succeeded not because they enjoy a monopoly of aseptic technique, but of mechanical technique. In other words, the man who will master the numberless details of asepsis in experimental work on animals, where matters are more complicated than in human surgery, is probably the man who will master the delicate mechanics of the operation. The vessels are brought together with the least possible stretching or narrowing of the lumen, thus affecting the blood stream as little as possible. The foreign body is made less active as a foreign body by impregnating the silk with vaseline. The silk is so chosen as to fill the holes made by the needles and thus prevent the admixture of tissue coagulins from the vessel wall. Having excluded these factors, the deposition of blood platelets, which, I believe, always fills the wound of the intima at least, may perhaps be insufficient to cause the formation of fibrin and thrombosis.

The exclusion of these factors brings me to the consideration of a mechanical aid to blood vessel anastomosis, which is

commonly called the method of Payr, but which, if my literary researches are correct, should be accredited to von Quirolo, his report appearing in 1895. The method consists in drawing the cut end of the vessel through a tube of glass, or ivory, or metal; the internal diameter of this tube is the same as the external diameter of the blood vessel. The vessel is then turned inside out, back over the tube, so that the intima is on the outside. This cuff is fastened in place by a ligature, and is then inserted into the other end of the blood vessel, which is fastened in its place by a second ligature. The ligatures are prevented from slipping off the little tube by placing them over grooves cut in the tubes, or back of a raised thread made on the outside of the tube. By this method broad surfaces of endothelium are placed in contact, and no wounds are made by the needles; the cut edges of the vessel, exuding coagulins, are entirely outside the vessel lumen. The method does not appear to have given especially good results except for temporary anastomoses, as in transfusion, where it seems to me to approach the ideal. It is not so easy to execute as it may seem. Crile has improved upon the original suggestions by attaching a handle to the tube, which greatly facilitates the eversion of the vessel.

The theories of the coagulation of the blood have carried me far out to sea; I was left there by the following facts concerning an operation little known, because of no practical importance. In 1876 a Russian army surgeon named Eck conceived the idea of making an artificial opening between the portal vein and the vena cava, in order to relieve the congestion in the portal system in cases of cirrhosis of the liver. He not only conceived this idea but executed it experimentally; and since that time the operation has been often performed, yet in no report do we find that thrombosis or embolism has resulted.

The operation has been done in several ways, none of which is calculated to prevent thrombosis. The vessels are brought together by interrupted sutures; wires or threads are then placed in position in the lumen of each vessel so that

when the small scissors, the blades of which are fastened to the wires, are drawn through, after a second row of sutures has been laid, each blade must cut a linear incision through the wall of its respective vessel, an incision limited by the points of entry and exit of the guiding wires; the line of this incision is then enclosed by a second row of interrupted sutures parallel with the first, and the scissors are pulled through between the two rows of sutures. In my own method the wire of an electro-cautery is substituted for the scissors. The portal vein is then tied off at the hilus of the liver, thus forcing all the blood through a torn or burned wound through all the walls of the veins. The interrupted sutures also pierce the intima.

We have then a beautifully torn, rough wound, sutures with no attempt to neutralize their action with vaseline, undoubted coagulation,—since we have no hemorrhage between the sutures, which are laid from one-sixteenth to one-eighth of an inch apart,—and yet no thrombosis. The explanation may be that the portal vein has no collateral branches to open and enlarge, and the blood is forced to pass through this artificial opening; but on the other hand the pressure cannot be so great as it is in an artery. It might be that the portal blood contains peptone-like bodies which inhibit coagulation, but this is hardly probable, for the portal blood coagulates outside the vessels as rapidly, if not more rapidly, than does blood from any other vessel. I have thought that the burned wound made by my cautery sealed the edges so that the tissue coagulins could not exude; yet equally good results have been obtained by using scissors; further, I have attempted to prove my idea by cutting the vessels of the neck with the cautery, and then joining them according to various methods; the results are possibly not so good as after the vessel wall had been severed by a sharp scalpel. In short, I am willing to admit that the processes governing thrombosis are not sufficiently clear to my own mind.

For the practical surgeon I feel that we may draw these conclusions: in any case where the anastomosis of a blood vessel is indicated, it should be tried; aneurisms and secondary

hemorrhages should not occur. If immediate thrombosis occurs we would be as well off as though the vessel had been ligated; if gradual thrombosis occurs, we might well hope that such a process would be more favorable to the formation of a collateral circulation than would immediate ligation; and if we should succeed, the literature of surgery would undoubtedly be enlarged and enriched.