Surgery of the vascular system / by Bertram M. Bernheim.

SURGERY OF THE VASCULAR SYSTEM

B. M. BERNHEIM, M.D.

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OF THE

VASCULAR SYSTEM

BY

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WITH 53 ILLUSTRATIONS IN TEXT

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TO

H. M. B.

PREFACE

The field of blood-vessel surgery offers great possibilities for future development, if this present early period of growth is not impeded by attempts on the part of unskilled operators to practise it. Brilliant laboratory results achieved in this work have often lured the inexperienced to try their luck, only to find that chance here plays no part and that success is measured only by years of trial, first in the laboratory, then in the clinic.

This book is intended to be a practical and suggestive aid to the surgeons interested in this branch of work; in it the various methods employed in the field of vascular surgery will be explained as simply as possible, a fundamental knowledge of the condition in hand being always taken for granted. For example, in considering the subject of aneurisms, the anatomical, pathological, and etiological sides, already described by other, more authoritative, writers, will be omitted; and in the descriptions of operative procedures where several methods have been devised, the one or two best and most employed have been selected for detailed exposition. This course has been pursued not to spare the writer wearying labor, but to present directly to the reader a text unhampered by preliminary review and multiplication of detail.

It is a pleasure to gratefully acknowledge the interest which Dr. W. S. Halsted, himself one of the pioneers in modern vascular surgery, has shown in my work; to thank Dr. John M. T. Finney for his sympathetic help and the clinical opportunities which he and Dr. J. C. Bloodgood have afforded me; to acknowledge my large debt to Dr. Harvey Cushing, during whose direction of the Hunterian Lab-

oratory for Experimental Medicine my research work was performed.

The enthusiastic co-operation of Mr. James F. Didusch, who, under the supervision of Mr. Max Broedel, furnished the illustrations for this book, has been much appreciated.

BERTRAM M. BERNHEIM.

BALTIMORE, 1913.

BRIEF HISTORICAL NOTE

A GRADUAL process of evolution, similar to that which took place in intestinal and other branches of surgery, has given rise to the present-day technic in blood-vessel work. The names of Eck, Glück, Hunter, Jassinowsky, Doerfler. Murphy, Jaboulay, v. Hirsch, Payr, Höphner, and others will always be closely linked with this development, which, because no consistently successful method of suturing vessels could be devised until a perfect asepsis had been achieved, marks a real triumph in modern medicine. After the attainment of this most important goal, perfect asepsis, a method simpler than all those previously suggested, became the method of choice, and the general technic developed by Carrel in working up his simple end-to-end suture (1905) formed the basis for all future endeavor in this field.

Inspired to renewed efforts by the achievements of Carrel, and founding their work upon his tenets, workers in clinics the world over have carried out many brilliant researches. Numerous modifications of his suture method have been suggested, for example, those of Payr, Dorrance, and others, and to a certain extent have been adopted, but all have lacked that perfect simplicity so characteristic of the Carrel method and so essential to success in vascular surgery.

Previous to the work of Carrel the chief interest in blood-vessel surgery centred about the treatment of aneurisms, and the names of Antyllus, Moore, Corradi, Macewen, Keen, Halsted, Matas, and others are closely connected with this branch of the subject. Now aneurisms, important as is their consideration, demand only part of our attention—for the subject has widened to include the repair of injured blood-vessels, the transplantation of arterial or venous segments

between the ends of a resected vessel, end-to-end or lateral anastomosis, and direct transfusion of blood. The operation of transfusion, employed from authoritative records as early as 1492 in a vain attempt to save the life of the then Pope Innocent VIII, has throughout the history of surgery never been lost sight of as a possible procedure, but has always failed of consistent results, until the work of Crile, in our own day and country, put it upon the basis of safety and practicability.

This brief review must convey the forcible impression of work only begun, and I feel sure that it will be the privilege of some not too distant chronicler to include in his records great progress in this branch of our endeavor.

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SURGERY OF THE VASCULAR SYSTEM

CHAPTER I

General Technic

General Considerations.—The success of blood-vessel work, anastomoses, transfusions, repair of injuries, etc., depends almost entirely on the avoidance of a blood-clot—and a general technic has been evolved which if properly observed gives most consistent results.

The wall of a blood-vessel, it is well known, is made up of three separate and distinct layers of tissue,—intima, media, and adventitia—each of which can be readily separated from its neighbor. Of these three coats the adventitia, or outer layer, is by far the most important to the surgeon engaged in vascular work, because, made up of a most delicate network of fibrous tissue, it hangs over the end of a severed and collapsed vessel, and acts as a sieve for the smallest drop of blood and as a nucleus for the formation of a clot. Its flaccidity would seem to render its removal an easy matter, and so it does; but this very characteristic, this very mobility, causes still more of it to slip into the needle hole, and if great care be not taken it acts as the starting point of a thrombus in an otherwise perfect suture. True, the scratched intima is an ever-present source of danger, as shown in the classic work on "Thrombosis and Embolism" of Welch, but one has only to consult the works and writings of those who have done pioneer work in the field of vascular surgery to realize that neither the intima nor the media is greatly to

be feared. The adventitia is the chief foe, and a worthy one at that.

Blunt Instruments.—Perhaps the first principle to be learned is that blood-vessels resent being handled by any other than blunt instruments, and of these instruments the fingers are the most useful and the safest. I am well aware of the fact that this dictum is diametrically opposed to present-day teaching regarding surgery in general, but a careful consideration of all the factors involved has led me to express this view. The blood-vessel wall is only too easily crushed; it should, therefore, never be grasped by a sharp-

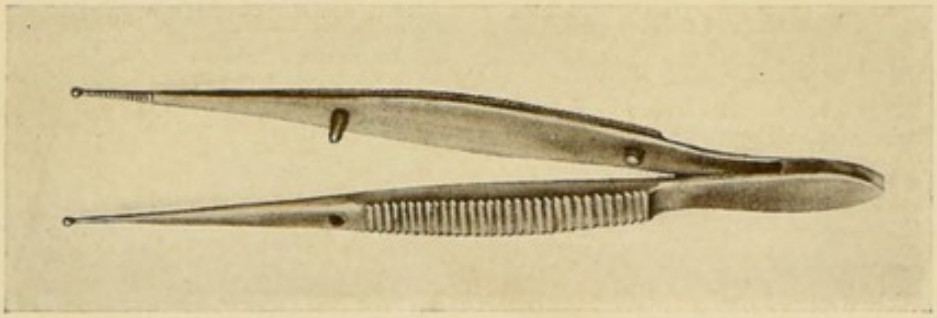

Fig. 1.—Author's ball-tipped forceps. Prevent injury to vessel wall, especially scratching of intima.

pointed or mouse-toothed forceps. But since the work can at times be facilitated by a delicate pair of forceps, I have had one constructed which has a small, polished metal knob about the size of an ordinary pin-head on each end. These knobs enable one to grasp the vessel firmly without doing the slightest damage to the intima (Fig. 1). Small branches should be utilized to lift the mother trunk, or a blunt dissector can be gently inserted beneath the vessel, which can then be raised or put on the stretch with impunity, so long as gentleness is employed.

After a vessel is thus exposed, and has once been mobilized to a certain extent, it can be grasped with the thumb and forefinger. At times it may be more convenient and equally efficacious to insert a soft tape (one-fourth inch

wide) beneath the vessel and use it as a tractor. Thus an artery or vein can be dissected out of its bed without the slightest instrumental insult.

Salt Solution and Liquid Vaseline.—During the entire course of any operation involving blood-vessels, the hæmostasis must be absolutely perfect, or as nearly so as possible. All branches, large and small—capillaries excepted—should be cut between two clamps and tied. Despite these precautions, however, there will always be a certain amount of staining, which is best removed with gauze sponges wrung out in normal salt solution. In addition to this a stream of warm salt solution should be played on the wound at intervals during the entire course of the operation, especially after exposure of the vessels. This is not alone for the purpose of removing blood and clot, but to prevent drying of the tissues as well—a phenomenon that occurs with striking rapidity in wounds of this character, and one that is to be avoided at all costs. Indeed, so careful must we be in this respect that we have called to our aid another agent better qualified to prevent drying than salt solution—liquid vaseline,[1] a neutral lubricant that keeps the tissues soft and pliable, prevents too rapid evaporation, and is tolerated by the organism in almost any quantity. The combination of salt solution and liquid vaseline, each judiciously used, keeps the wound in a beautiful state of pliability that renders all manipulations much easier to accomplish and less liable to damage any of the delicate structures handled.

Handling the Severed Vessel.—If care is necessary in handling the vessel intact, the utmost consideration must be exercised in dealing with it severed. Intima must not be scratched, and yet all blood and every vestige of fibrin must be scrupulously washed out of the vessel. Salt solution

[1] I use that made by Chesebrough Manufacturing Company of New York.

thrown on and into the vessel by a blunt-tipped rubber syringe together with restrained stripping with the fingers works wonders, but the overhang of adventitia that occurs as soon as the vessel is cut and soaked in salt solution obstructs the lumen to such a degree that complete cleansing is impossible until it has been removed. This is accomplished by grasping it with the thumb and forefinger, or a very delicate pair of mouse-tooth forceps, drawing it well down over the end of the vessel,—it comes down with remarkable ease,—and cutting it off flush with the cut edge. Thus freed from adventitia the mouth of the vessel will at once spring open, permitting the insertion directly into its lumen of the perfectly rounded tip of a medicine dropper filled with salt solution. This is repeatedly injected until all clot and visible fibrin are washed out, whereupon the lumen is filled with liquid vaseline. Even before all clot is displaced it is well to inject a little vaseline into the vessel and around the field of operation in general.

Blood-vessel Clamps.—The blood flow is at all times to be obstructed by a rubber-shod clamp, of the variety shown in the illustration. The smaller, or so-called bull-dog clamp, is used on small vessels like the radial, while the larger, or Crile clamp, is employed for vessels of larger calibre. If the jaws of these or other clamps are not serrated, they need not necessarily be rubber-shod, but I have always preferred to use a clamp armed with rubber, believing that it is safer. At times it may be inconvenient or even impossible to use any clamp, in which case the ordinary tape mentioned above when properly placed around the vessel and secured by an ordinary hæmostat, will act as a safe and effectual clamp.

Suture Material.—Suture material must be light and delicate, yet strong enough to withstand any arterial pressure. Such a silk is the 00000 made by Belding Bros. & Co., of New York. It can be obtained in either the white or black, is beautifully smooth, withstands sterilization without

loss of strength, and has answered every purpose, both experimental and practical. This silk is nicely carried by a No. 12 ground down needle that is made by H. Milward & Sons. This needle has a small round eye, and is one inch long—a length that permits of just the right amount of flexibility.

It is my custom to use black thread,[2] since that can be seen against a white background much more easily than a white thread against a black background, the latter being Carrel's method. I have noticed absolutely no difference in the healing or in the operative results following the use of either the white or the black thread; the dye in the thread used for blood-vessel suture is fast and almost infinitesimal in amount.

FIG. 2.—Needle and thread mounted and ready for sterilization.

All needles are threaded and sterilized in liquid vaseline before operation, the routine being to thread each needle with about twelve inches of the black silk, drawing the ends even and fixing each needle on a separate piece of ordinary writing paper, about one-half inch by one-quarter inch, in such a way that the doubled thread is wound around the needle by a figure-of-eight (Fig. 2), and the final end of the thread caught by a slit in one corner of the paper. Thus prepared, four threaded needles are placed in a small flask containing one or two ounces of liquid vaseline (Fig. 3) and sterilized in the usual way. Just before operation the contents of one or more flasks, oil as well as needles, are poured into a dry sterile medicine glass and placed on the instrument table. I have made it a rule to allow no one but myself to touch these needles at operation, and I leave them lying in the oil until the time for actual suture comes, when I carefully remove

[2] The thread and all instruments used in vascular work are handled by the Chas. Willms Surgical Instrument Company, of Baltimore.

one needle from its paper by going through the reverse figure-of-eight. One end is then shortened to about two inches, and the needle and thread are given a final inspection for any defects, such as small spots of rust or inequality or roughness in the silk. If this examination is satisfactory the suture is begun, a similar procedure being observed for each additional suture that may be needed.

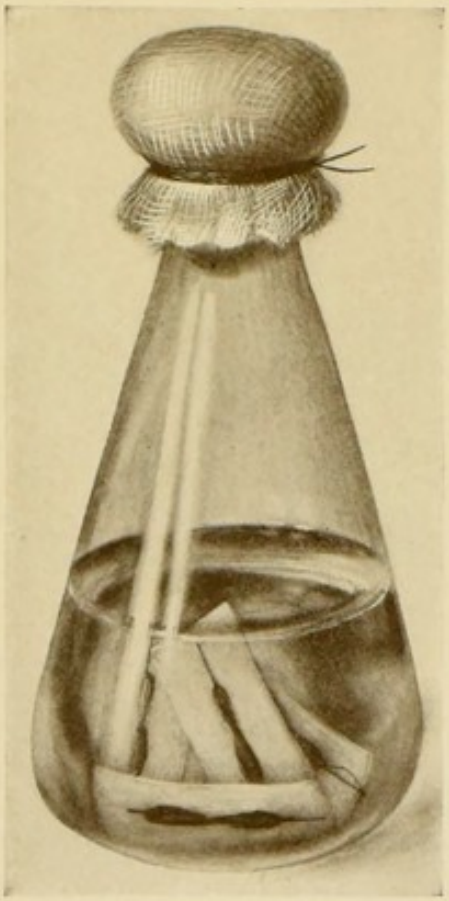

Fig. 3.—Flask containing liquid vaseline and four mounted needles. Sterilized and kept as stock.

Rubber gloves are generally worn in blood-vessel operations up to the point of actual suture, though sometimes only to the point where the washing-out process of the vessels begins. Their discard at this point is at present an unavoidable and unfortunate break in technic, which I endeavor to minimize by a preparation of the hands lasting not less than twenty to twenty-five minutes. The delicacy of the manipulations and the fineness of the needles and thread necessitate the use of the bare hand, and in order that the skin of the hands may be soft and pliable, it is well to wash them in salt solution immediately after discarding the gloves and then anoint them thoroughly in the liquid vaseline, this process being repeated as often as they become dry. Attention to these and many other details that experience alone can teach is required to secure constant results in this field of surgery, but success will more than compensate for the patience and energy it demands.

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CHAPTER II

Transfusion

Transfusion, the most employed operation in blood-vessel surgery, has presented gratifying results, and in the hands of the careful surgeon is capable of lasting and far-reaching effects.

Transfusion means the giving of blood by one individual to another, and there are two methods by which it is accomplished, (1) direct and (2) indirect. When the blood-vessels of one individual are directly united with those of another, whether by suture or cannula method, and blood flows from one to the other, we call the procedure *direct transfusion;* when blood is withdrawn from one individual by means of a needle and syringe and, after being defibrinated, is injected into another individual, we call the procedure *indirect transfusion.* I shall deal exclusively with the direct method, which is, at present, thought by surgeons to give better and more far-reaching results than the indirect method. Indirect transfusion in selected cases and handled properly is also of great service.

To illustrate the use of this operation I wish to state that it shows gratifying success in cases of hemorrhage; for example, in those tragic cases where fresh blood has been the only means of making up the deficiency caused by accident; in cases of bleeding from a gastric ulcer; typhoid ulcers; ruptured extra-uterine pregnancies; and in other conditions. This emergency use of transfusion in saving life after loss of blood covers only part of the field; transfusion has repeatedly been successfully employed to raise the resistance of patients too weak to withstand the shock of a necessary operation. A case in point is that of a boy aged seven (pa-

tient of Dr. J. M. T. Finney) who, suffering from splenic anæmia, had become so dreadfully exsanguinated from repeated hemorrhages from the stomach that his hæmoglobin was too low to register. A splenectomy was successfully accomplished by Dr. Finney during the course of a transfusion, and the boy not only withstood the operation but was in better condition at its conclusion than at the start. He made a stormy but successful recovery, only to succumb five months later from another gastric hemorrhage, probably the result of an old œsophageal varix.

The anæmias—pernicious anæmia, leukæmia—have not responded well to this operation, but the number of reported cases upon which this conclusion is based is very small. It is possible that in certain of these and other allied anæmias transfusion may be of great service.

Therapeutically the outlook is bright; for example, transfusion is most auspicious in hemorrhage of the new-born—melæna neonatorum. The depleted circulation in such cases is not only restored but the obscure condition itself is cured in almost all cases. Hæmophilia in general is another illustration of the beneficent influence of this operation and certain cases of illuminating gas poisoning, as shown by Crile, can be resuscitated by this means. Beneficial results, even a certain number of cures, have been attained in pellagra following transfusion. Cole reports a number of apparent cures and I have had one myself.[1] Shock, that most dreaded and most baffling condition of all surgical complications, can frequently, when all other measures for its relief have been unsuccessful, be overcome by prompt transfusion. Certain of the toxæmias would seem to be amenable to this form of treatment. I have recently transfused in a case of toxæmia of pregnancy

[1] It is impossible to say just how or why transfusion is of service in this condition. It hardly seems likely that it acts as a specific. A more logical deduction would be that it raises the resistance of the patient by restoring the blood picture more nearly to normal.

with a most promising outcome. Thus far, only the borders of the field of transfusion have been opened up by pioneers. It lies full of promise, inviting exploration.

Fig. 4.—Crile cannula.

A number of instruments have been devised for the purpose of simplifying transfusion, each one with a certain degree of merit. I have selected for description those three which I considered as easiest to manipulate and as giving most favorable results.

First comes Crile's cannula (Fig. 4), most widely employed since it was the first clinically successful instrument. Dr. Crile, who has described the technic of its use in a number of papers and finally in his excellent mono-

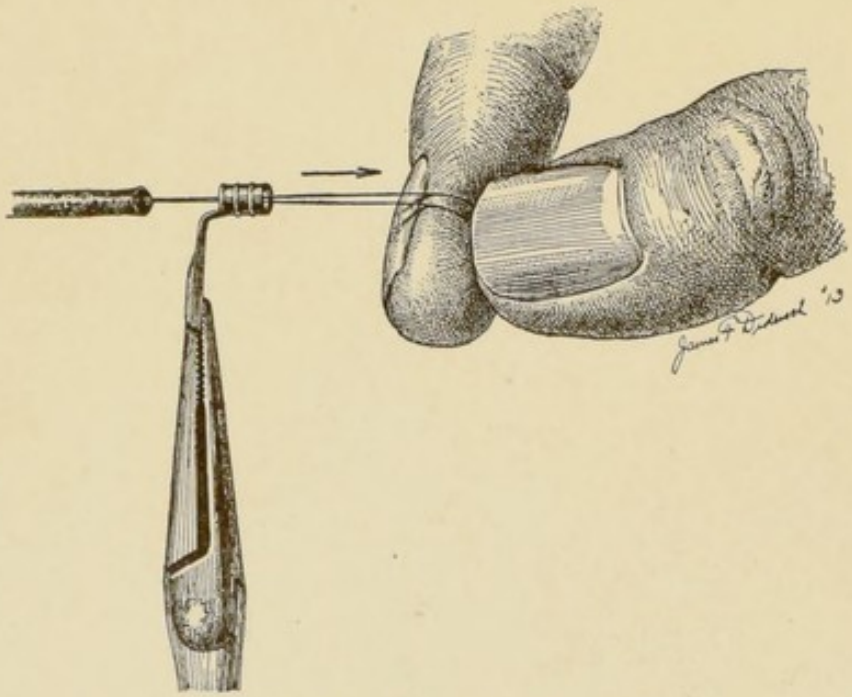

Fig. 5.—Drawing vein through cannula.

graph "Hemorrhage and Transfusion" (1909), briefly explains as follows:

"The vessels to be anastomosed are exposed (for details see page 16) and, after selection of a cannula of size suitable to the size of the vessel, the end of the vein is pulled through

the handle end of the tube by means of a single fine suture inserted in its edge (Fig. 5), the needle being left on the suture and passed through the cannula ahead of the vein. The handle of the cannula is then tightly seized by a pair of hæmostats, three mosquito hæmostats are snapped at equidistant points on the end of the vein, taking care not to have the tips extend up into the lumen more than is necessary

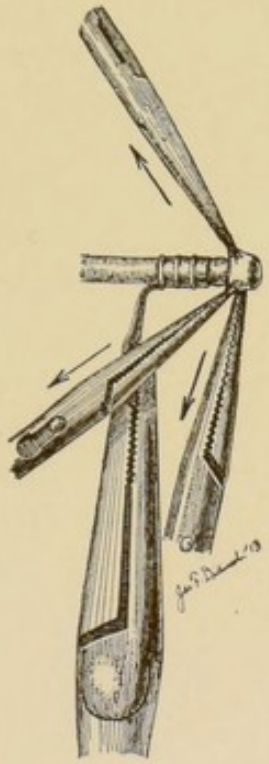

Fig. 6.—Cuffing vein back over the cannula.

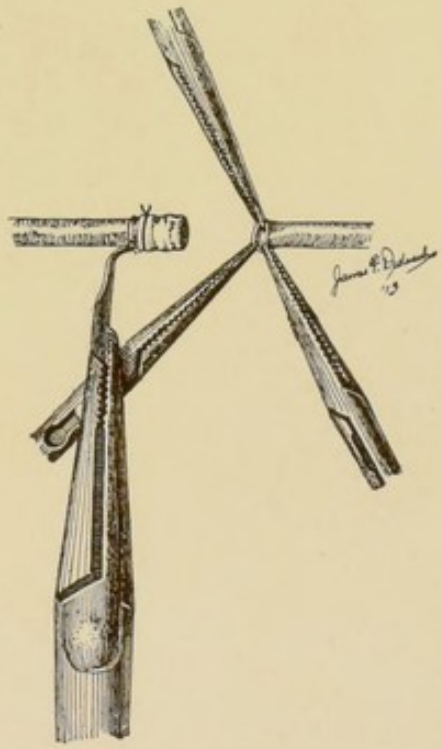

Fig. 7.—Vein cuffed and tied in groove nearest handle of the cannula. Artery grasped by three mosquito clamps.

to get a firm hold. The end of the vein is then cuffed back over the cannula by gentle simultaneous traction on the three hæmostats (Fig. 6) and tied firmly in place with a fine linen thread in the groove nearest the handle (Fig. 7). The cuffed part is next covered with sterile vaseline, being careful not to get any into the open end. This facilitates slipping the artery over the cuff. The hæmostats are removed from the full edge and the artery may then be put in place.

"Owing to the elasticity of the arterial wall, it usually shrinks (contracts) considerably when the pressure from within is removed, as it is at the free end. To obviate this it may be necessary to dilate the end very gently by inserting the closed jaws of a mosquito clamp covered with vaseline and opening them for a short distance. The three hæmostats are applied to the edges, just as with the vein, and the artery is gently drawn over the cuffed vein on the cannula and tied in place with another fine linen suture applied in the remaining groove (Fig. 8). The mosquito hæmostats are removed, and finally the large hæmostat which has been snapped on the handle of the cannula during all this time is removed. The process is then completed. After the transfusion the cannula is removed, both artery and vein are ligated, and the wounds are sutured.

Fig. 8.— Artery slipped over cannula and tied in the second groove. Anastomosis complete.

"In making a cannula anastomosis, experience will show what size cannula is suitable for given vessels. As large a size should be used as possible, without injuring the intima of the artery by stretching it too much. Usually there will be no difficulty in obtaining a large vein, but the artery may be very small. If too small a cannula is used, the volume of flow will be diminished. Moreover, too large a vein will take up too much room in the cannula and the amount of flow will be diminished.

"The exposed vessels should be kept moist and warm with normal salt solution. Not only is drying harmful, but the flow is increased through gradual relaxation of the arterial wall.

"Experience has shown that if anything goes wrong in carrying out this technic, it is best to start again from the beginning, and not to try to get around any of the details by substitution."

It is occasionally quite awkward to properly "set" the

necessary ties on Crile's cannula. It was to overcome this difficulty that I modified his tube by placing three small hooks on the handle end of it (Fig. 9), thus avoiding the necessity of placing the ties by having each vessel in turn impaled on the hooks. Otherwise the technic of the two instruments is identically the same.

Fig. 9.—Author's three-pronged modification of Crile's cannula.

The second cannula is an ingenious device of Elsberg. It is built on the principle of a monkey-wrench (Fig. 10) which can be enlarged or narrowed to any size desired by means of a screw at its end. The smallest lumen obtainable is about equal to that of the smallest Crile cannula, and the largest greater than the lumen of any radial artery. The instrument is cone-shaped at its tip, a short distance from which is a ridge with four small pin-points which are directed backward. The lumen of the cannula at its base is larger than at the tip. The construction of the cannula can be easily understood from the following description of the method of using it:

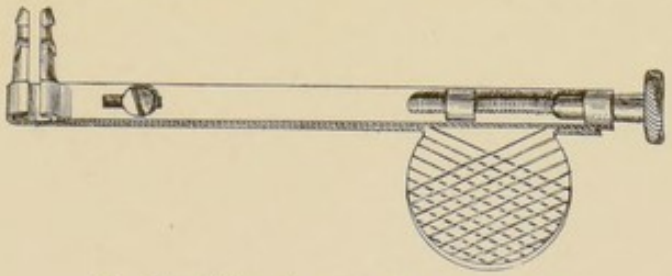

Fig. 10.—Elsberg's monkey-wrench cannula.

"The radial artery of the donor is exposed and isolated in the usual manner. The cannula, screwed wide open, is then slipped under and around the vessel. It is then screwed shut until the two halves of the instrument slightly compress the vessel (Fig. 11). The artery is then tied off about one centimetre from the tip of the cannula. Before the vessel is divided, three small-eye tenacula are passed through the

wall of the artery, at three points of its circumference, a few millimetres from the ligature. Small mosquito forceps may also be used. These are given to an assistant, who makes traction on them while the operator cuts the vessel near the ligature. The moment the artery is cut, the stump is pulled back over the cannula by means of the tenacula or forceps, and is held in place without ligation by the small pin-points (Fig. 12). There is no bleeding from the artery, even though no hæmostatic clamp has been applied, because the cannula itself acts as a hæmostatic clamp. The vein of the recipient

Fig. 11. Fig. 12. Fig. 13.

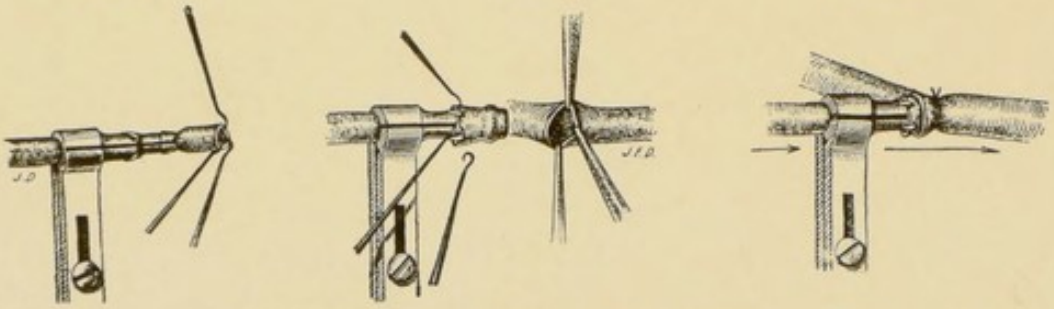

Fig. 11.—Artery "set" in Elsberg's cannula; tenacula in position for cuffing.
Fig. 12.—Artery everted and impaled on the hooks. Vein grasped by mosquito clamps.
Fig. 13.—Cannula slipped into side of vein and tied in position. Anastomosis complete.

is then exposed (but not freed), two ligatures are passed around it, one is tied peripherally in the usual manner. A small transverse slit is made in the vein, the cannula with the cuffed artery inserted into the vein, a ligature tied around the vein and cannula screwed open (Fig. 13), and the blood allowed to flow. The rapidity of the flow can be varied as desired by the size to which the instrument is screwed or unscrewed, and the lumen of the artery is never diminished.

"It will be noticed that the artery is cuffed instead of the vein; this method I believe to be more correct. The vein is the larger vessel and can therefore be more easily telescoped over the artery. The vein is only exposed, not freed, and the artery is intubated into it.

"With this cannula I have been able to make the anastomosis in less than four minutes after the artery had been

isolated, and have found the entire procedure a simple one. The advantages of the instrument are the following:

"(1) One cannula will fit any vessel.

"(2) The cannula is applied around the vessel instead of the vessel being drawn through the cannula.

"(3) No ligature of the cuffed vessel is required.

"(4) The cannula itself acts as a hæmostatic clamp.

"(5) The cuffing of the artery is easily accomplished without stripping back the adventitia, and, therefore, the traumatism to the artery wall is reduced to a minimum.

"(6) The vein need only be exposed, not dissected out and cut.

"(7) As the cannula is unscrewed the blood will flow, the flow can be regulated at will, and the lumen of the artery is not diminished."

I agree with Elsberg, in general, that it is preferable to cuff the artery rather than the vein, and frequently do practise this method. However, it is best to remember that in children (and even some adults) the vein is more delicate and smaller than the adult radial artery, and to adopt no inflexible rule in this matter. The operator must be prepared to adapt himself to the exigencies of the occasion.

The third instrument which I shall present is one of my own design. Simple in construction, large enough to work with comfortably, it requires a minimum of dissection and can be rapidly put into action. It is a two-pieced affair (Fig. 14), consisting of two hollow tubes, each 4 cm. long, and each bulbous at one end in order to form a neck for a retaining tie, and bevelled to facilitate entrance into the vessel; the other ends are tubular and fitted for invagination. The instrument was originally constructed in two sizes as regards the bore of the smaller ends, but experience has shown that either size will fit the vessels of any individual—from an infant up to an adult.

My reason for having an instrument thus constructed in

two separate parts was twofold. Firstly, in transfusing an infant, it is usually difficult to make the actual union of vessels with a small instrument like that of Crile or Elsberg because of the smallness of the parts and the delicacy of the infant's vessels. Paraffined glass tubes answer the purpose fairly well, but paraffine is not always at hand, nor is a suitable glass tube, and, if it is, the probabilities are that it will be chipped or broken. Secondly, for emergency work I believe that a cannula constructed in two pieces, one of which can be rapidly inserted into the artery of the donor, and the other into the vein of the recipient, by separate crews of operators, is best. Even in cases where haste has not been so urgent,

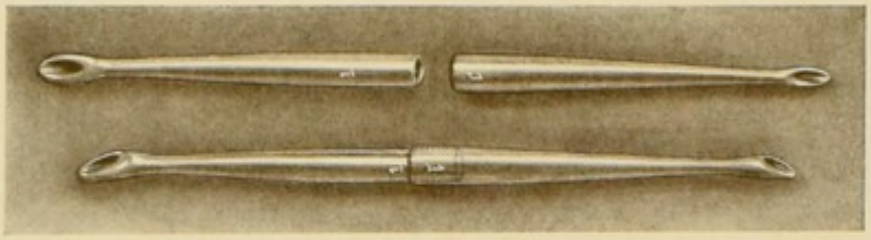

Fig. 14.—Author's two-pieced transfusion tube.

the ordeal for the recipient, who is usually anxious and in a precarious state, can be materially relieved by preparing the donor completely before bringing the recipient into the operating room, or even by preparing the two entirely in separate rooms, simply wheeling the stretcher of the donor into the recipient's room, placing them in apposition, and invaginating the two halves of the cannula—a matter of only a few seconds.[2]

The technic, then, of a transfusion by means of this two-pieced cannula, as well as the management of transfusion in general, is as follows: The radial artery of the donor is usually united to one of the superficial veins at the elbow of

[2] An additional advantage possessed by these tubes is that the vessels of donor and recipient do not come in contact, there being a distance of about an inch or inch and a half between them. This is a great comfort in those cases of infectious diseases—typhoid, streptococcus, etc.—where every precaution must be taken to protect the donor against infection.

the recipient; occasionally, because of infection at the elbow, it becomes necessary to employ a vein of the leg, generally

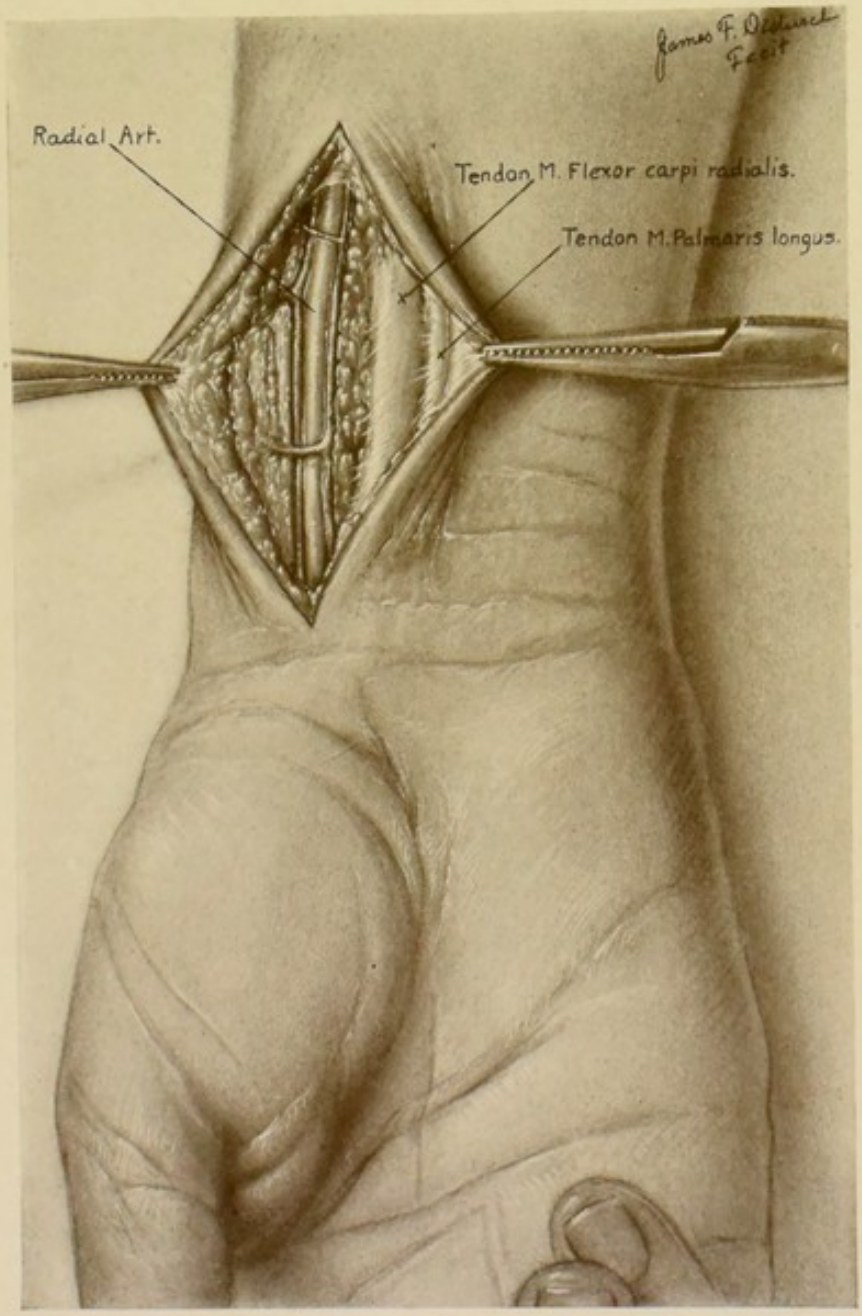

Fig. 15.—Incision in wrist of donor, showing radial artery and venæ comites.

the internal saphenous, although any available vein may be used. But no matter whether it be arm to arm, or arm to leg, in preparing the patients let the watchword be "*left* to *left*,

right to *right*"—in other words, the left radial should always be united to a vein of the left arm or leg and *vice-versa;* a few moments' thought will show the anatomical reasons for this. Other things being equal, it is always wise to leave the choice of radials to the donor, but where he (or she) has no choice, it is my rule to utilize the left radial, if the patient be right handed and both radials are of the same size (which by the way is not always the case), his right if he be left handed. Thus the donor will be incapacitated as little as possible during the healing of his wound—a detail, perhaps, but one that ought to be considered.

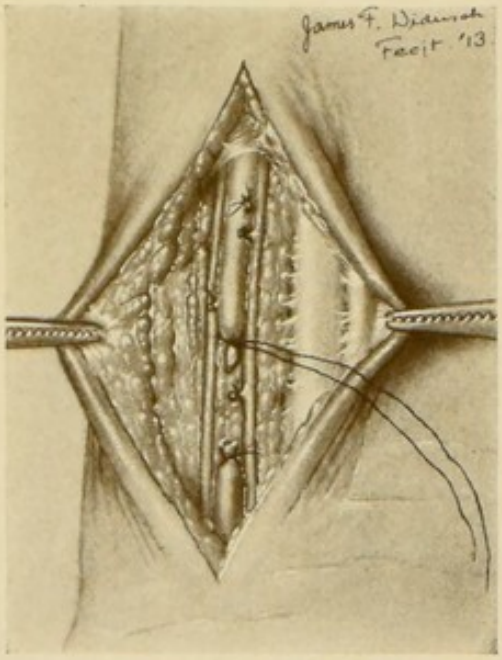

FIG. 16.—Radial artery separated from venæ comites, doubly ligated, and divided.

Time will be saved if the radial is dissected out as follows, novocain (0.5 per cent.) being the anæsthetic of choice: (1) expose the artery with its accompanying veins for a distance of about two inches (Fig. 15), (2) free the artery from the veins and tie off all branches doubly with very fine silk, cutting between the ties; (3) tie off the artery doubly at the distal end of the wound and cut between ties, thus allowing about one and one-half inches of the vessel to lie free in the wound (Fig. 16); (4) tie off all bleeding points in the wound, and keep a constant stream of warm salt solution flowing over the artery, all sponging being done with gauze moistened in the same solution; (5) place a bull-dog clamp on the vessel at the proximal end of the wound.

Up to this point the technic is the same no matter which method of anastomosis is to be used. If my two-pieced

cannula is to be employed, a small cut is now made in the upper side of the artery with a fine pair of scissors, the opening being made at right angles to the course of the vessel and about half its width (Fig. 17). Next, every visible trace of blood is immediately washed out with warm salt solution and liquid vaseline, the latter being injected into the lumen

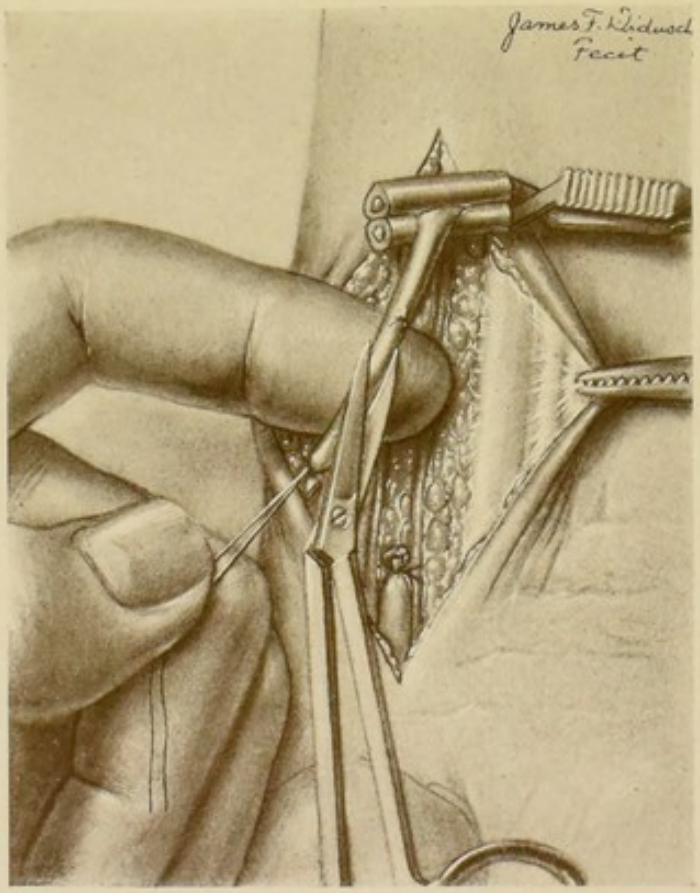

Fig. 17.—Cutting oval opening in side of radial artery.

of the vessel with a medicine dropper at frequent intervals during the washing process. It keeps the vessel soft and pliable, and prevents too rapid evaporation and consequent drying. Any little bit of adventitia that may get into the opening should be carefully pushed away or cut off.

The vessel having been carefully prepared, the bevelled end of the male half of the tube is inserted into the artery (Fig. 18) and held there by a tie thrown around its neck

(Fig. 19). Liquid vaseline is now again injected into the vessel through the tube, and the whole thing wrapped in salt-solution gauze to await the completion of a similar preparation of the vein of the recipient. It is hardly necessary to dissect out more than one inch of the vein, and, as this is always quite superficial, the time required for the whole

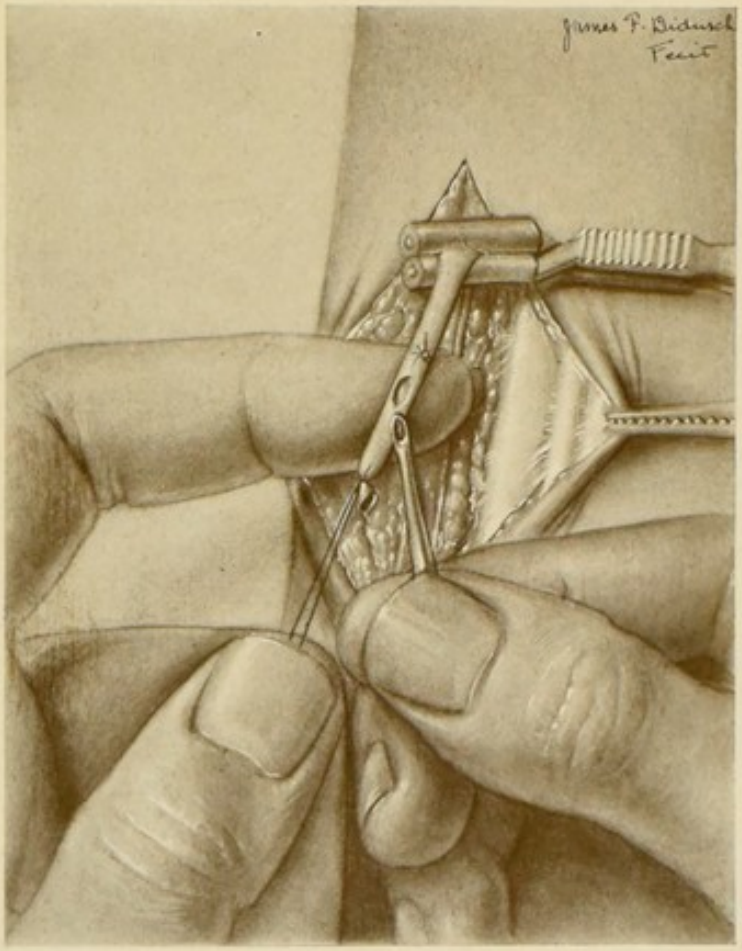

Fig. 18.—Slipping male half of tube into the artery.

procedure of dissection, cleansing, and insertion of the female half of the tube (Fig. 20) amounts to hardly more than five minutes.

When both patients have been prepared, their stretchers are brought into apposition and the two arms are placed on a table about one foot broad. With a little manipulation the wrist of the donor is brought into such proximity to the

elbow of the recipient that the tubes can be invaginated (Fig. 21) to the proper degree. When this is accomplished, a steady stream of warm salt solution is started flowing over the artery, tubes, and vein, and the bull-dog clamp is removed from the vein, its place being taken by the thumb and first finger of the right hand of the operator. With great care the clamp controlling the arterial flow is now gradually released, coincidently with which the thumb and finger controlling the vein gradually ease up, thus permitting the blood to go over gradually, so as to prevent any possibility of swamping or embarrassing the circulation of the recipient by a sudden gush of blood under great pressure. Let it be strongly emphasized here that, with few exceptions, the margin of safety is none too great in any transfusion at any stage. It is my custom, therefore, to control the inflow in the manner above described during the *entire* course of the transfusion.

FIG. 19.—Tube tied in place in the artery.

If assistants are at hand, the blood-pressure and pulse of the recipient should be taken at intervals of every three minutes, that of the donor every five minutes. These measures cause but slight annoyance to the patients and are of the utmost importance to the surgeon in judging the condition of both individuals. Hæmoglobin and red counts, made during the course of the operation, although they are interesting and valuable do not give nearly so helpful immediate information as do blood-pressure and pulse, and, since they cause more or less discomfort to the patients, we do not make these readings unless there is some special reason for them. It is unnecessary to say, of course, that the blood-

pressure and pulse of both donor and recipient have been taken before starting the transfusion, as a control, and that

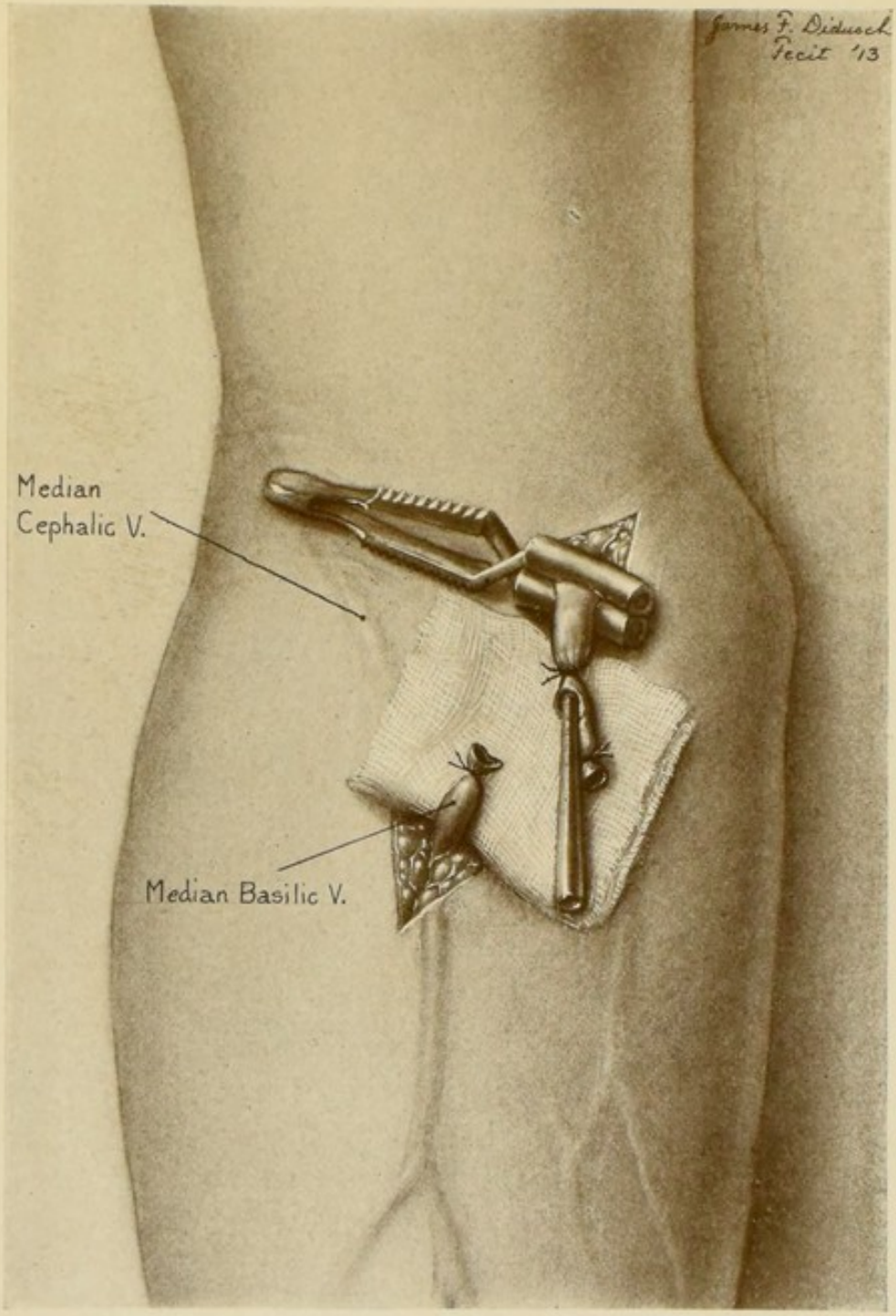

Fig. 20.—Female half of tube tied in position in vein of the recipient.

if the facilities are at hand, a complete blood examination—reds, whites, and hæmoglobin—has been made of both pa-

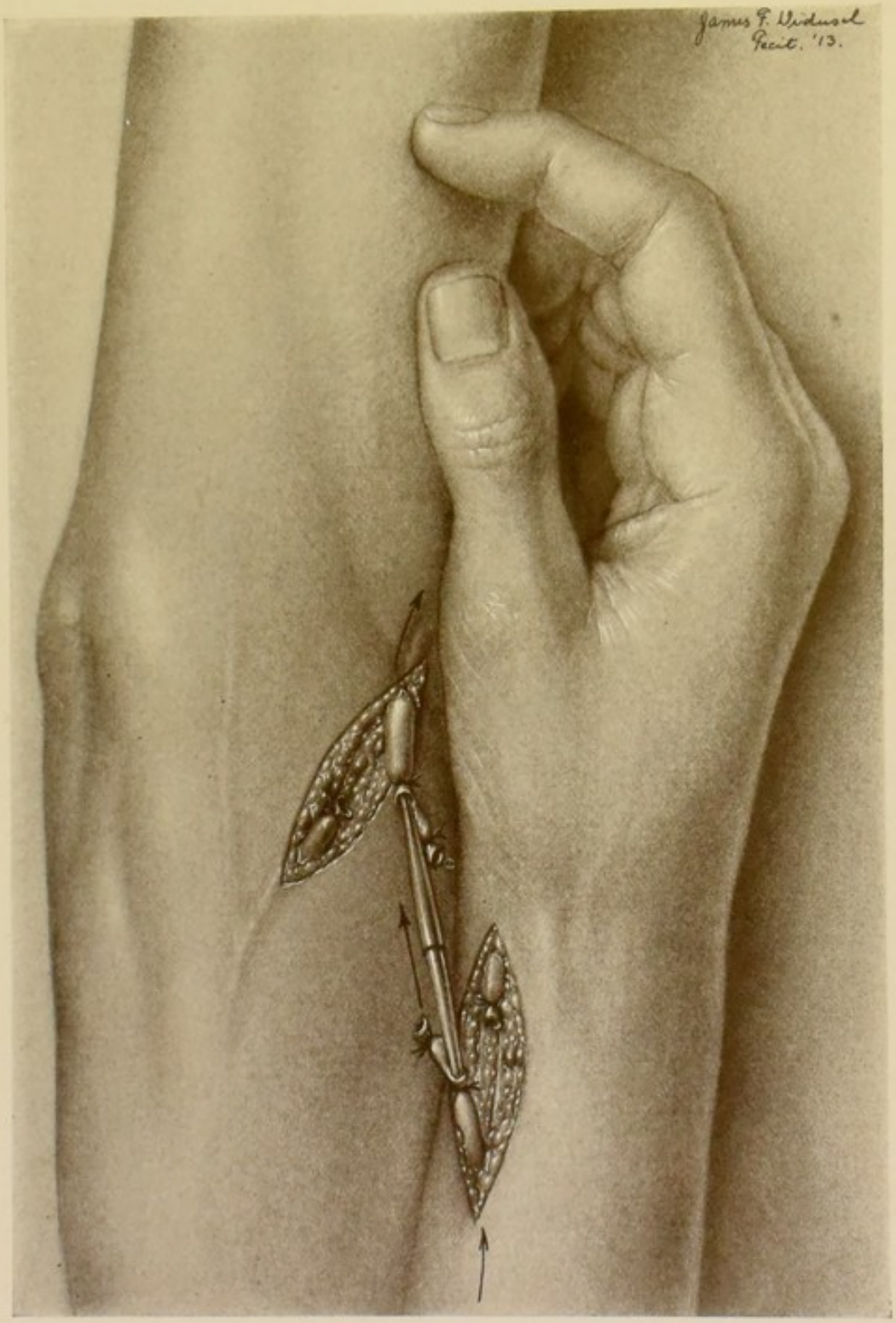

FIG. 21.—Tubes invaginated and anastomosis complete.

tients, also as a control, for, after completion of the transfusion, these data are most valuable in interpreting both the immediate and future results of the operation.

Where the recipient is practically exsanguinated, and there is no contraindication, it is wise to give him all the blood he can conveniently hold, even occasionally (Crile) going to the extent of using two donors in case one cannot stand any great loss of blood. My routine is to attempt to bring a pulse of say 150 or 160 down to about 100 and to raise a blood-pressure of 50 to 70 up to 110 or 120, figures well within the zone of safety.

It sometimes happens that it is decidedly unwise, even hazardous, to overload the circulation, an example of such a case being a patient exsanguinated as a result of hemorrhage from typhoid (or other) ulcers of the bowel. To give such an individual much blood would be tempting fate, whereas a small amount, sent in slowly, will decrease the coagulation time, and seal up the mouths of open vessels with life-saving thrombi. In other words, a great amount of blood will simply raise the blood-pressure to such an extent that it will literally blow out any soft young plugs that might be all that is holding body and soul together.

It is a most difficult matter to judge as to the exact amount of blood that has gone or is going over. No practical method of measuring the amount of blood flow has been devised, and until this much-desired instrument is placed at our disposal we shall be compelled to depend upon clinical signs for an index of the amount of blood transfused. It must be recognized that a number of factors must of necessity enter into any calculation of bulk. The blood-pressure, because of the psychic disturbance in every operation of this sort, is by no means constant. The loss of blood is another, perhaps the chief, factor in determining the instability of the blood-pressure and therefore the amount that goes over in bulk. The pulse-rate varies, too, from time to time and this must be considered in any determination of amount. There are still other factors, such as the viscosity of the blood, etc., which need not be considered in a work of this

character. It is sufficient to say that to the careful, experienced surgeon all the factors above mentioned can be determined with a surprising degree of accuracy by the thumb and forefinger guarding the entrance at the vein. This knowledge and constant observation of the actual blood-pressure reported by the assistants, the general appearance of the patients, and the actual time that the blood has been flowing —all this serves as a guide to the amount of blood going over and the proper time to cease transfusing.

In regard to the duration of actual flow in transfusion in general, there are various questions to be considered. An infant will require but a small amount of blood, children need far less than adults, and, as a rule, women less than men, always considering that the patient is exsanguinated. A big husky man will generally have a larger radial than a small man, and his pressure will enable a much larger and more powerful stream to be thrown by his vessel. Likewise, a female donor may give less blood in a given time than a man—provided the man is not too badly frightened. Thus the actual time of transfusion varies, from three to five minutes to one hour or even an hour and a quarter, if a very small cannula is used, or if the blood has been permitted to go over very slowly. For most transfusions the average duration of the flow is from twenty to forty minutes.[3]

The welfare of the donor in transfusion must be carefully watched. I have transfused from one donor for over an hour without any signs of distress, while in another case fifteen minutes were sufficient to produce great anxiety. In general a sudden fall of twenty to thirty points in blood-

[3] I have proved both experimentally and clinically that, if the proper technic has been observed, blood will flow through my two-pieced cannula from fifteen to thirty-five minutes without clotting. When a clot does occur, it requires but a few moments to remove the tubes, wash out both vessels with salt solution and liquid vaseline, and insert another set, the flow being again started in the usual manner. Even when there is no clot I have occasionally found it of advantage to arrest the transfusion for five or ten minutes in order to ease and reassure the patients.

pressure should warn the operator that the limit has about been reached. Unfortunately, however, a blood-pressure apparatus is not always at hand and even where it is the fall in pressure, sudden or gradual, does not always occur. In such instances any sudden pallor, accompanied by nausea and vomiting, continued and increasing thirst, great restlessness, together with a decrease in blood-pressure as shown by the finger of the operator on the donor's radial, may serve as the needed danger signal. The bleeding should never be permitted to exceed the limit of safety; the donor ought never be allowed to collapse utterly. A proper appreciation of his own responsibility as well as the moral rights of those courageous individuals, generous enough to give of their own blood that another might live, should always be pre-eminent in the mind of the surgeon who undertakes work of this nature.

The danger of hæmolysis following transfusion has always been vastly over-rated and unwarrantably feared. In a rather large series of transfusions, done for the relief of many and varied conditions, I have never seen it occur, and I know of but one authentic instance where it complicated matters. This was in a case of Dr. John L. Yates of Milwaukee (personal note), who transfused a patient exsanguinated as a result of hemorrhage from a gastric ulcer. There was a rather marked but temporary hæmolysis following the operation, the patient making a good recovery. Crile reports a personal case in his book on "Hemorrhage and Transfusion" and calls attention to its occurrence, although he, too, regards it as more of a theoretical than a practical menace.

I believe that the proper course to pursue—and have so practised—is to have the hæmolytic tests of donor's and recipient's blood made, if the case is not urgent and when the proper facilities and trained laboratory workers are at hand. If the case is urgent, I never even consider such a

thing as hæmolytic tests, contenting myself with a most careful physical examination of the donor in order to rule out the possibility of transmitting syphilis or some other disease to the recipient; for it must be remembered that hæmolytic tests, even at best, are not entirely conclusive, and do not absolutely protect against hæmolysis. The blood of one individual may hæmolize that of another in the test tube, but not in the body after transfusion, and, *vice versa,* the laboratory tests may pronounce an individual a suitable donor, and yet hæmolysis may occur after transfusion. So that until some absolutely reliable, uninvolved test has been found, the rather remote danger of hæmolysis may be disregarded in emergency cases, in the home, and in institutions where the facilities for making these tests are not at hand.

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CHAPTER III

End-to-End Suture

Classical End-to-end Suture. Exposure of Vessel; Washing Process.—During the exposure of a vessel all sources of hemorrhage should be scrupulously controlled, the tissues should be handled gently and sponged with gauze, wet with normal salt solution. For an end-to-end suture of an artery two Crile clamps, armed with soft rubber tubing, should be applied, the moment the vessel is sufficiently exposed, at a distance of about two inches apart, all branches that come off between them being clamped, tied, and severed. The vessel is then divided (Fig. 22) and the blood immediately washed out of both ends with normal salt solution, eye droppers or pipettes armed with rubber bulbs being found most suitable for this purpose. If their ends have been previously carefully rounded by flaming they can be introduced within the lumen of the vessel without danger of injuring the intima.

Treatment of Adventitia.—This washing is done with the utmost care, but is usually interfered with by a soggy layer of whitish tissue hanging over the end of the vessel and more or less obstructing the lumen. This is the adventitia, which, practically devoid of elastic tissue, fails to contract on severance of the vessel and drops lifeless over the cut ends, thus obstructing the way. It should be picked up with the first finger and thumb, or preferably with a delicate mouse-toothed forceps, pulled well out over the ends of the vessel (Fig. 23), and snipped off flush with the cut edge (Fig. 24). Occasionally all of it will be gotten the first time, but if any loose edges are left they should again be treated

in the same way, following which, with a delicately pointed forceps, the remaining adventitia should be stripped back well away from the cut edge. During this time, which in reality consumes only a minute or two, the washing process should be continued by an assistant. When

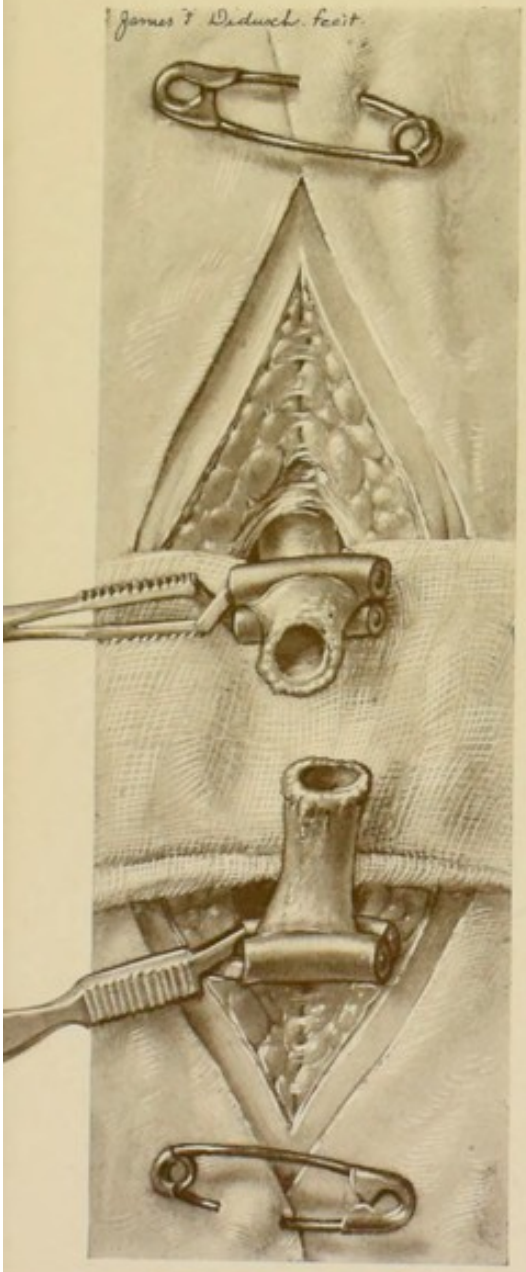

Fig. 22.—Severed ends of an artery showing the over-hang of adventitia.

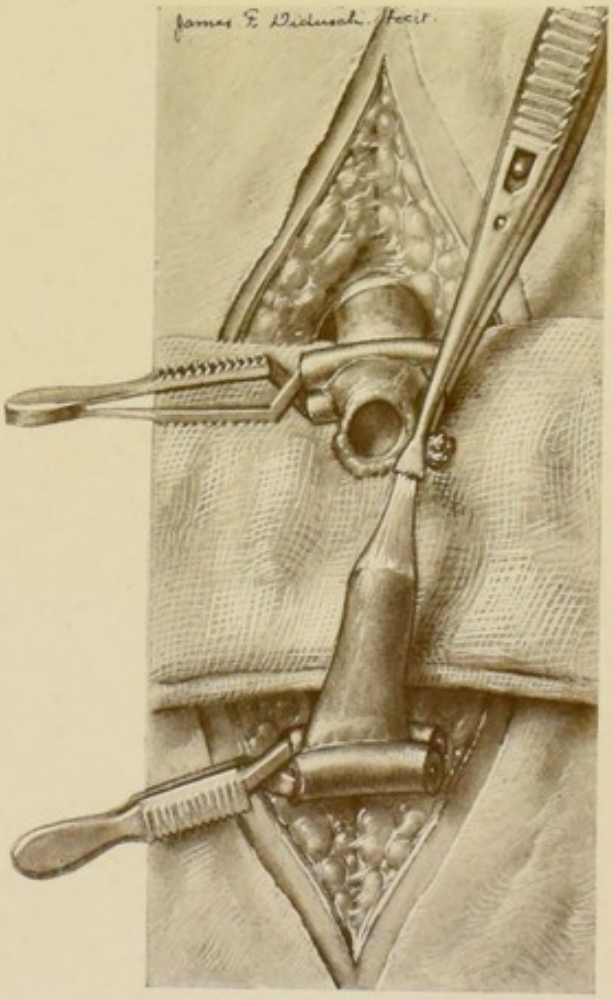

Fig. 23.—Drawing adventitia well out over end of the artery.

the adventitia is completely removed, the tip of the pipette should be inserted into the lumen of the vessel and every visible trace of blood washed out; then with another pipette

the vessel should be washed and soaked outside and inside with *liquid vaseline* to prevent drying and keep the tissues soft and pliable (Fig. 25). The process of washing and soaking with salt solution and liquid vaseline should be continued all during the process of the operation, and an eye should constantly be kept on the adventitia, which, despite the utmost care, will often literally creep down to the cut edge and insinuate itself in the line of suture.

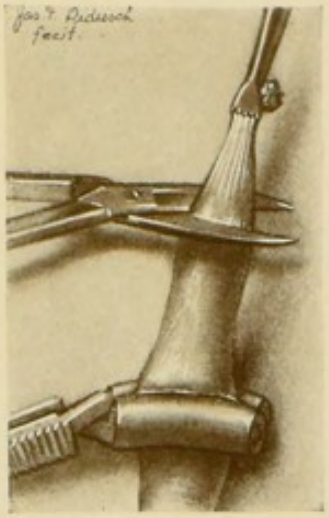

FIG. 24.—Cutting off adventitia flush with end of the artery.

Stay Sutures; Formation of Triangles.—Following the technic so beautifully developed by Carrel—and later by Stich—the cut ends of the vessel or vessels, *e.g.*, artery or vein, to be united are first brought together by three stay sutures placed at points equidistant around the lumen (Fig. 26). These sutures, passed in such a way that the knots will be on the outside of the vessel, are tied (Fig. 27), and the union is then secured by sewing in succession each side of the triangle thus formed, using either one continuous thread with a tie at each stay suture, or using the long end of each stay to sew the corresponding side of the triangle. During the process of the suture,[1] the operator holds in his left hand one stay suture while the assistant holds in his hand the corresponding one, thus forming a straight line of the edges to be sewed (Fig. 28). A light clamp should be allowed to hang on the third stay in order to keep the other edges from being caught in the stitch.

Over-and-over Stitch.—As one side is finished the next

[1] In all drawings of anastomosis in this and succeeding chapters the femoral vessels are taken as a type.

is brought into position by rotation of the stay sutures (Figs. 29 and 30). At each stroke the needle passes through all

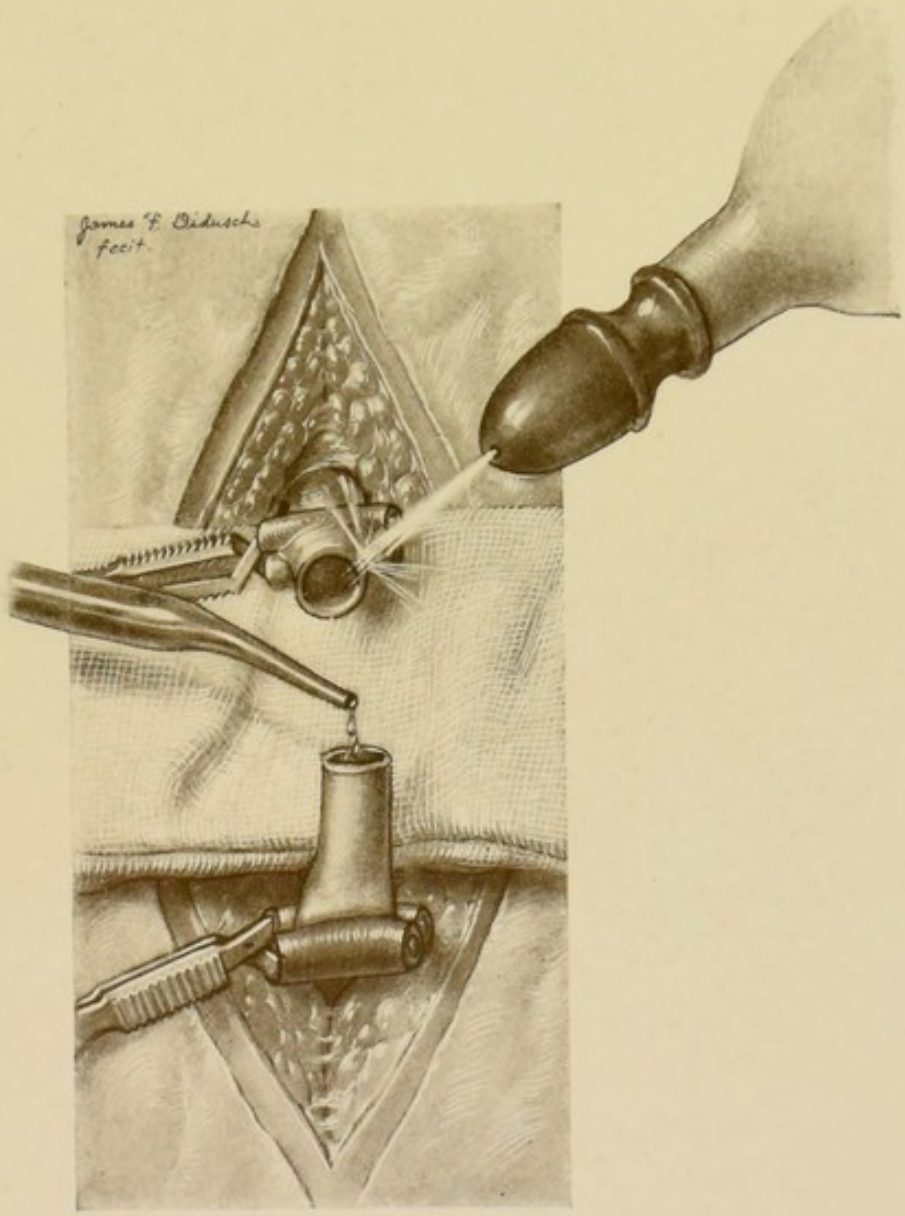

Fig. 25.—Washing out vessels with liquid vaseline and salt solution.

three coats of both vessels, starting on the outside of one, and ending on the outside of the other, thus placing all knots outside the lumen. The stitch is a simple over-and-over one,

each needle hole being placed just far enough back from the cut edge of the vessels to secure comfortably all three coats. No set rule can be laid down as to the number of stitches in any one side of the triangle or in the whole triangle; this must of necessity depend on the size of the vessels, but the

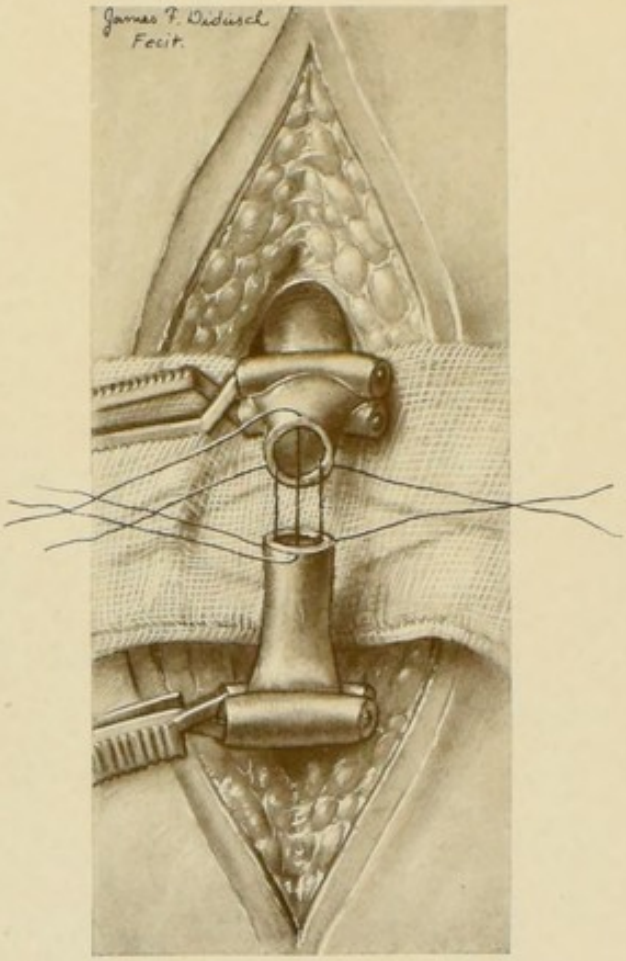

Fig. 26.—Three stay sutures placed.

sutures must neither be placed too close together nor too far apart. The approximation of the cut edges of the vessels should and can be made so perfect that almost no irregularity is apparent to the naked eye (Fig. 31). Despite all caution,

however, it frequently happens that after the blood flow is started there are one or two little leaks that must be caught up with an interrupted stitch. This is best done

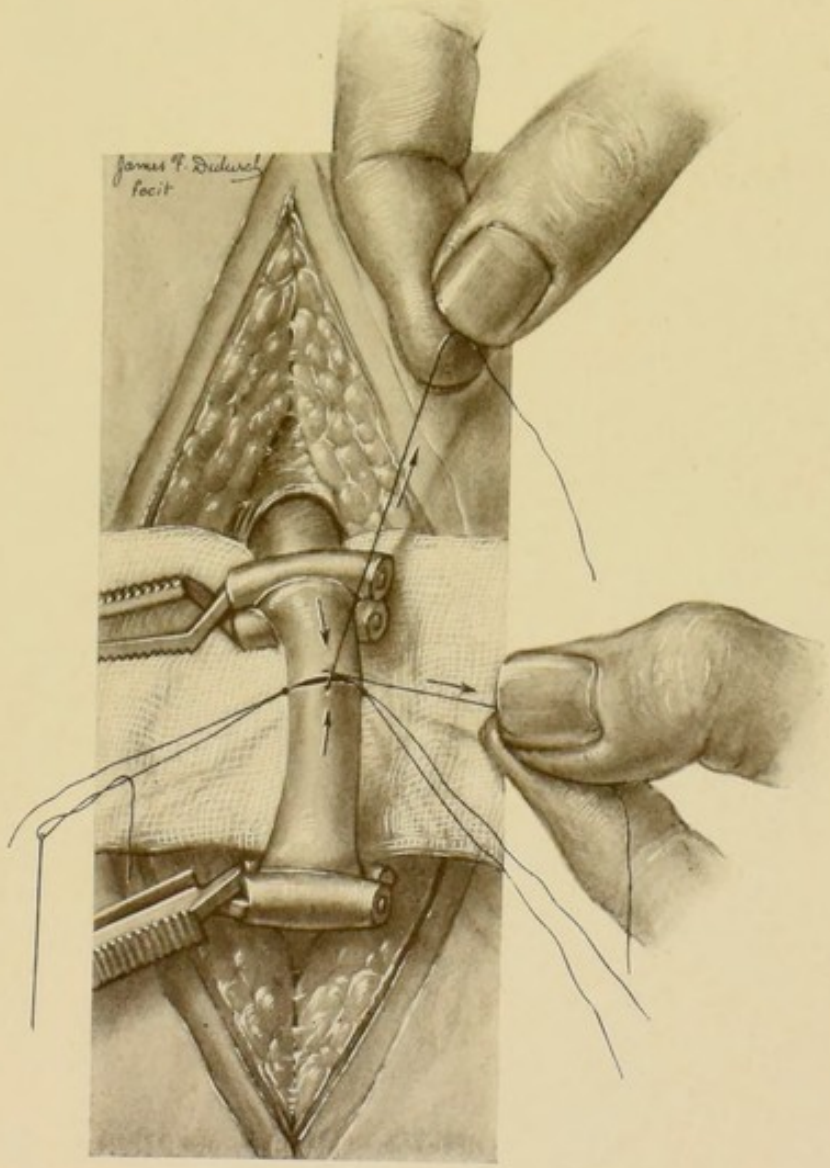

Fig. 27.—Stay sutures tied and vessel triangulated.

during a temporary interruption of the circulation, and if the usual care be observed no apprehension need be felt by operator.

Toilet of Completed Line of Suture.—Before placing any

secondary sutures, however,—really before allowing the blood to flow,—the line of suture should be carefully wrapped in dry gauze and a slight compression exerted in order to throw

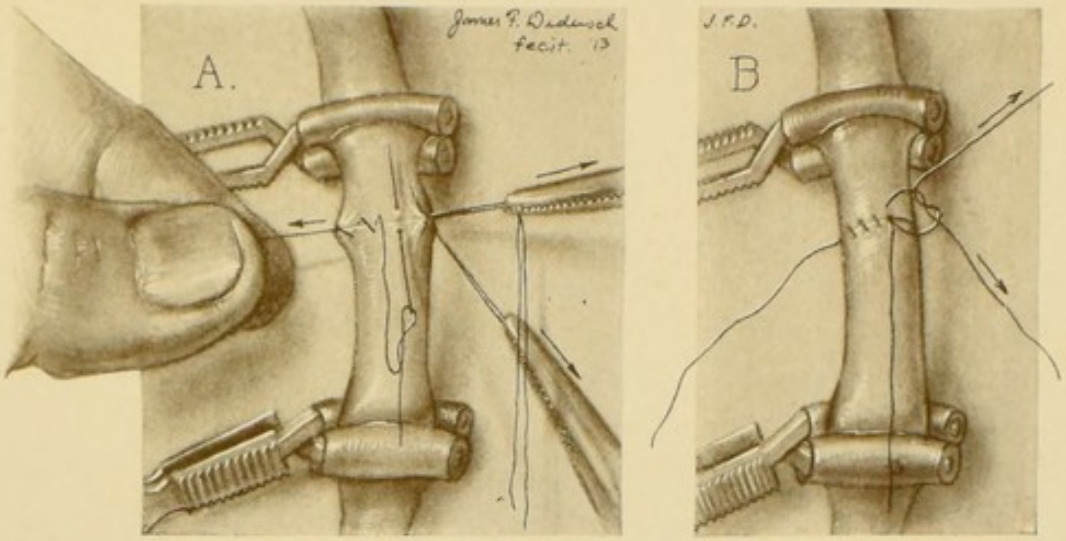

Fig. 28.—Sewing first side of triangle.

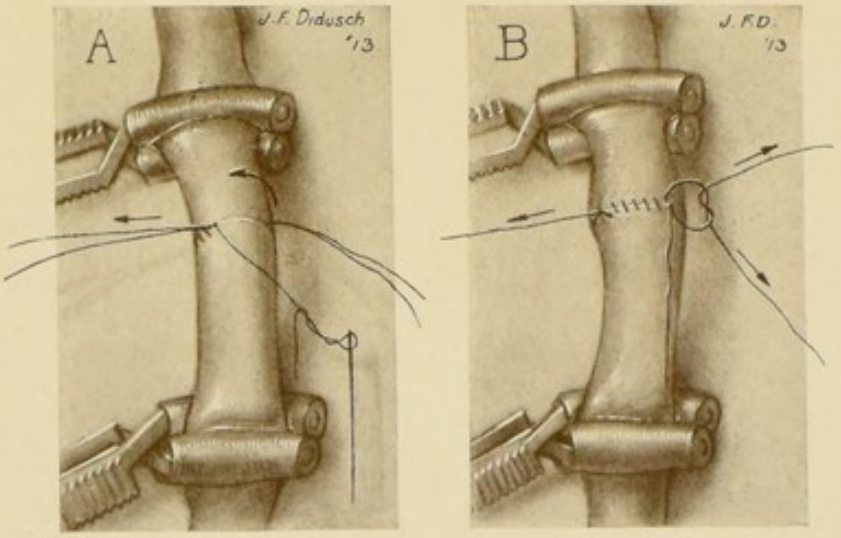

Fig. 29.—Sewing second side of triangle; vessel partially rotated. A tie is placed at each stay suture.

the whole strain of the circulation gradually on the sutures. A gentle rolling motion—massage-like—is given the vessel at the same time, the whole process being continued for about

five minutes, during which time the little needle holes and any interspaces that are not too large will fill up with clot. If this seemingly small detail is conscientiously carried out and a gradual relaxation allowed to follow, many a secondary stitch that under other circumstances would be needed may be avoided. It might be added that in starting the blood flow after the completion of a suture the *distal* clamp should always be released first; otherwise the sudden rush of blood, peremptorily checked just an inch or so beyond the line of suture, will throw a terrific strain on the line of suture that is both unnecessary and dangerous. Any one who can perform this classical end-to-end anastomosis successfully need have no hesitation about attempting the other methods, for mechanically they are all easier to carry out, and the general technic is identically the same.

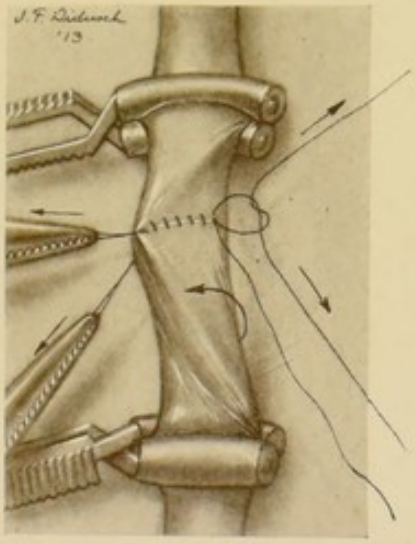

FIG. 30.—Sewing third side of triangle; vessel completely rotated. Instead of complete rotation, reverse rotation may be practised in order to bring the third side of the triangle into view.

FIG. 31.—Suture complete.

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CHAPTER IV

Lateral Anastomosis

Lateral anastomosis of blood-vessels is chiefly employed in uniting an artery with a vein, and only within the last year or so has serious attention been directed toward developing this suture to the same degree of perfection that has been attained with the end-to-end method. The tardy development of this operation can be explained by the fact that it has only become a working necessity since our recent realiza-

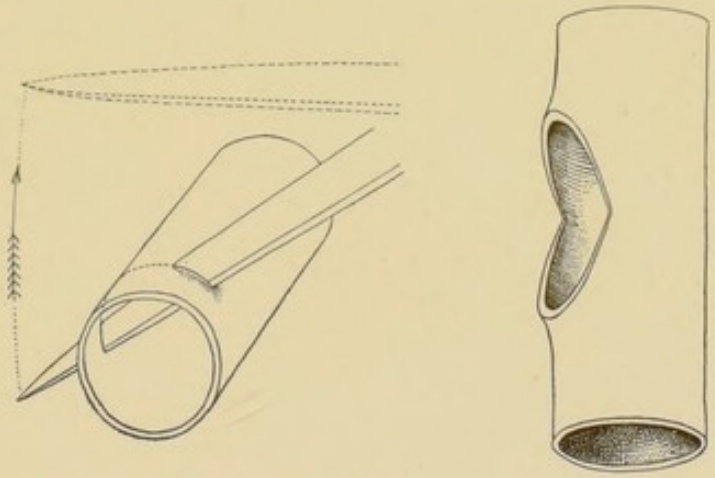

Fig. 32.—Diagram showing method and principle of making incision in vessels in lateral anastomosis according to the method of Bernheim and Stone.

tion that, in cases of threatened gangrene of the extremities, where arterial flow must be transferred into venous channels, this procedure (lateral anastomosis) seems not only theoretically more correct but gives better results in practice than the end-to-end suture (see chapter on Reversal of the Circulation).

Several methods of uniting vessels side to side have been suggested—one by Carrel, another by Hadda, still another by Jeger—but I believe that none answers the purpose so

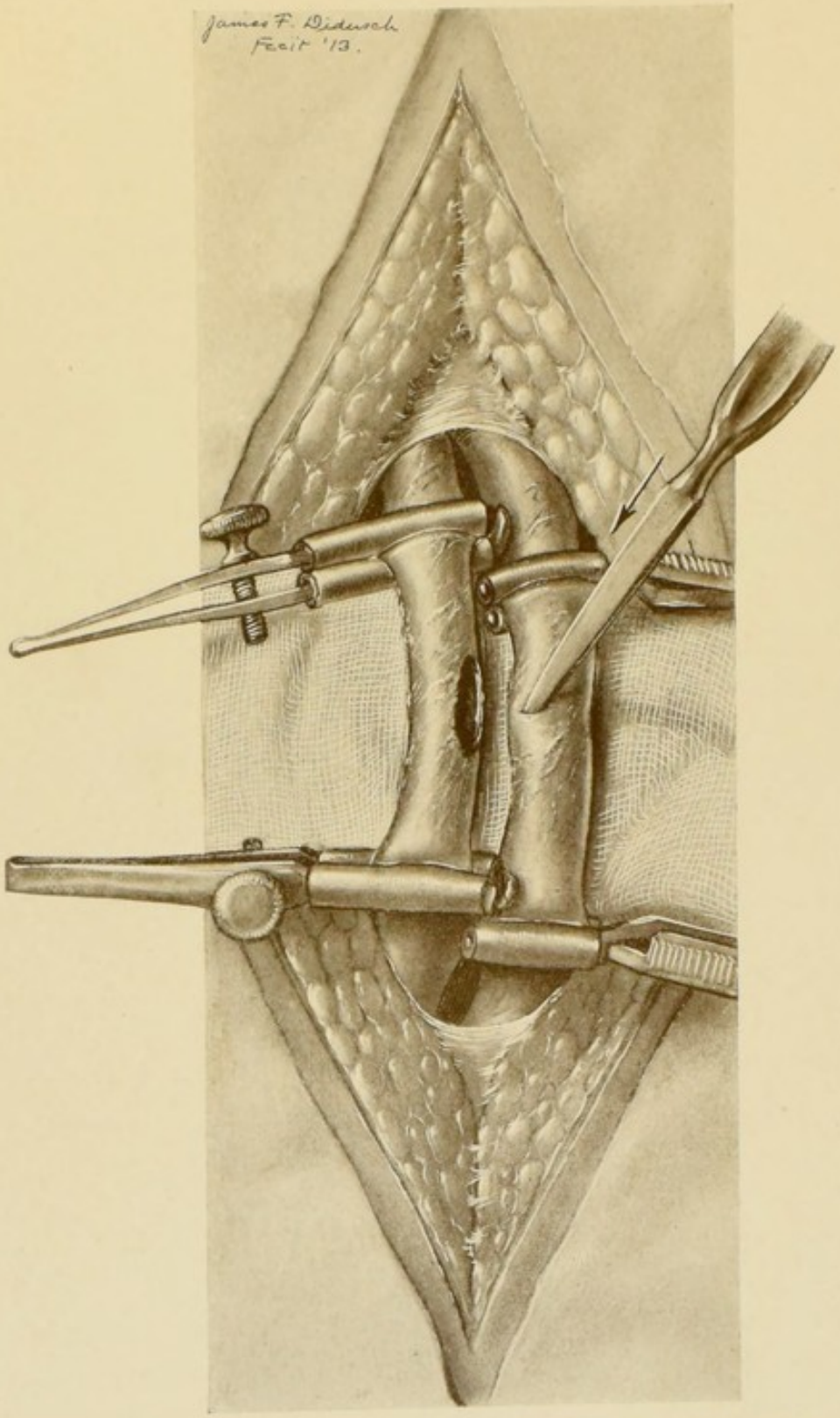

FIG. 33.—Incision made in side of artery and being made in side of vein.

well, theoretically and practically, as that devised by me, Dr. Harvey B. Stone collaborating, in 1910, the details of which are as follows:

The artery and vein between which the communication is to be established are carefully dissected out, and bull-dog or Crile clamps, rubber-shod, are applied to each vessel at corresponding points. The incision in the artery is made first. A sharp cataract knife, held transverse to the long

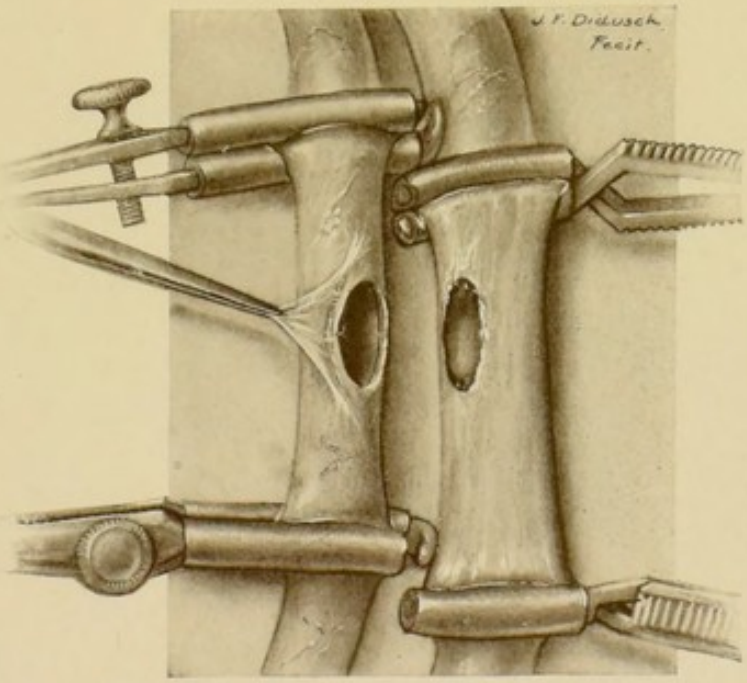

Fig. 34.—Drawing adventitia away from the oval opening.

axis of the vessel (Fig. 32), is plunged through the artery in a direction oblique to the horizontal plane in which the vessel lies, so as to form a sector of the lumen with its arc equal to about one-third of the circumference. The knife is thrust in with its cutting edge upward and toward the adjacent vein. The overlying one-third of the artery wall is then divided. At once the retraction of the longitudinal muscle and elastic fibres causes this transverse incision to gape and become an open ovoid. Owing to the fact that the knife was entered

obliquely and not perpendicularly, this ovoid (Fig. 33) looks toward the vein and also somewhat upward. The posterior edge of the opening is thus easily accessible for suturing. As soon as the artery is opened all blood is washed out with salt solution, the adventitia stripped off carefully (Figs. 34 and 35), and the lumen and other surfaces freely bathed with liquid vaseline (Fig. 36). The artery is then protected with vaseline-soaked gauze, and a similar incision, corresponding in size and position, is made in the vein so that it looks toward the artery and upward.

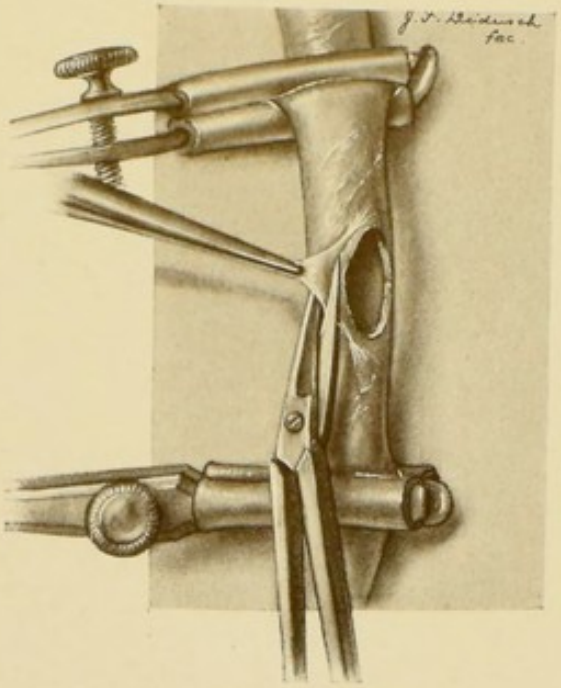

Fig. 35.—Cutting away the adventitia.

The suture is started by passing the needle through the wall of the artery from without inward, then crossing to the vein and passing here from within outward (Fig. 37). When this suture is tied the knot lies outside the vascular lumen. From this starting point a simple continuous suture (Fig. 38) is carried around the openings in the two vessels, care being taken to avoid purse-stringing[1] (Fig. 39). The operation is completed by tying the last suture to the remaining long end of the first tie (Fig. 40). No difficulty is experienced in approximating the edges of the incisions, and there is no more tension on the thread than in an end-to-end anastomosis. After completion of the suture, the proximal end of the vein having been doubly ligated with heavy silk about one-half

[1] In reality the thread is so delicate that purse-stringing is almost an impossibility.

to three-fourths of an inch above the site of anastomosis, the clamps are removed first from the vein, as in all vascular surgery. If any marked leakage occurs, the weak spots are reinforced by one or two extra sutures. Then the arterial flow is gradually allowed to go over (Fig. 41). During the suturing, intima is not always approximated to intima, but with the establishment of the arterial stream through the

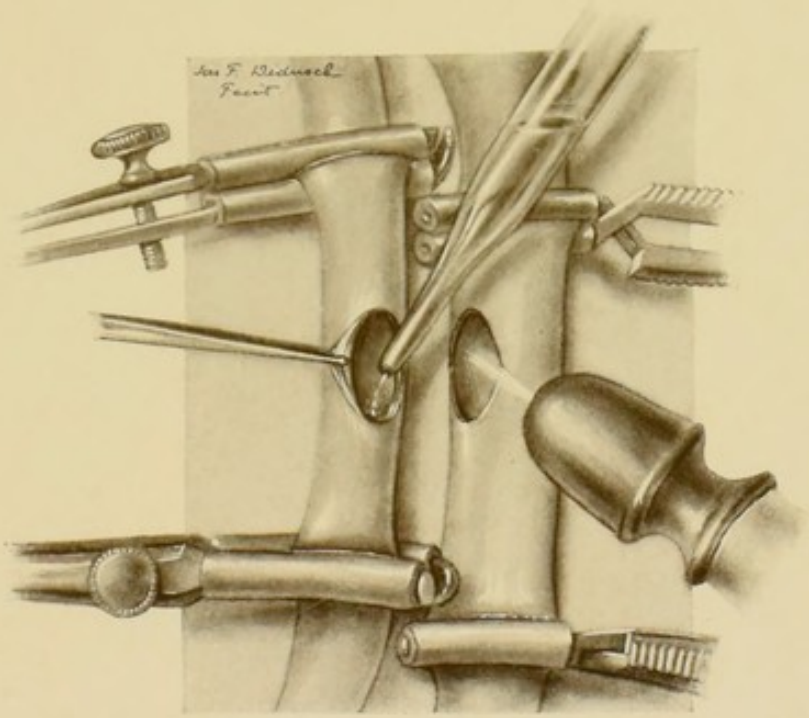

Fig. 36.—Washing out the vessel with salt solution and liquid vaseline.

anastomosis, the "pull" in opposite directions between the two vessels helps to bring about an accurate approximation.

This method has been employed with great satisfaction a considerable number of times in animals, and was equally simple in execution in the four clinical cases in which I have so far had the opportunity to try it. The rationale of this method has been deduced from a consideration of the cases of arteriovenous aneurism met with in the clinic. Previous laboratory anastomoses have been performed by making longitudinal rather than transverse incisions in the vessels. In the clinical cases following trauma there seems little doubt

that the wounds are transverse. A bullet, knife-blade, or other object wounds the adjacent surfaces of artery and vein

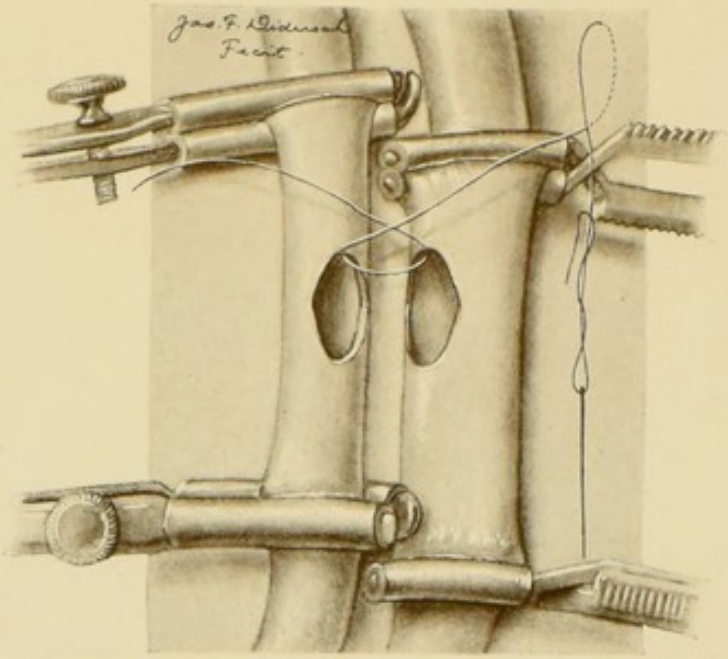

FIG. 37.—Starting suture of the vessels. The knot is placed *outside* the lumen.

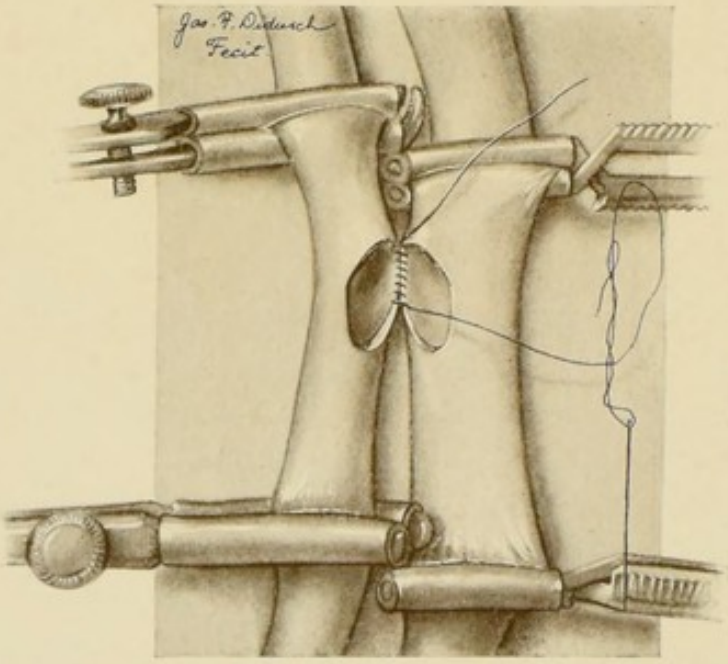

FIG. 38.—Posterior row of sutures being placed.

at the same level. The vessels are held closely together by their investing sheaths, the transverse incisions gape, as

illustrated in these sketches, and the gaping lips soon adhere. The method described in this paper is practically a copy of this accidental anastomosis occurring in nature.

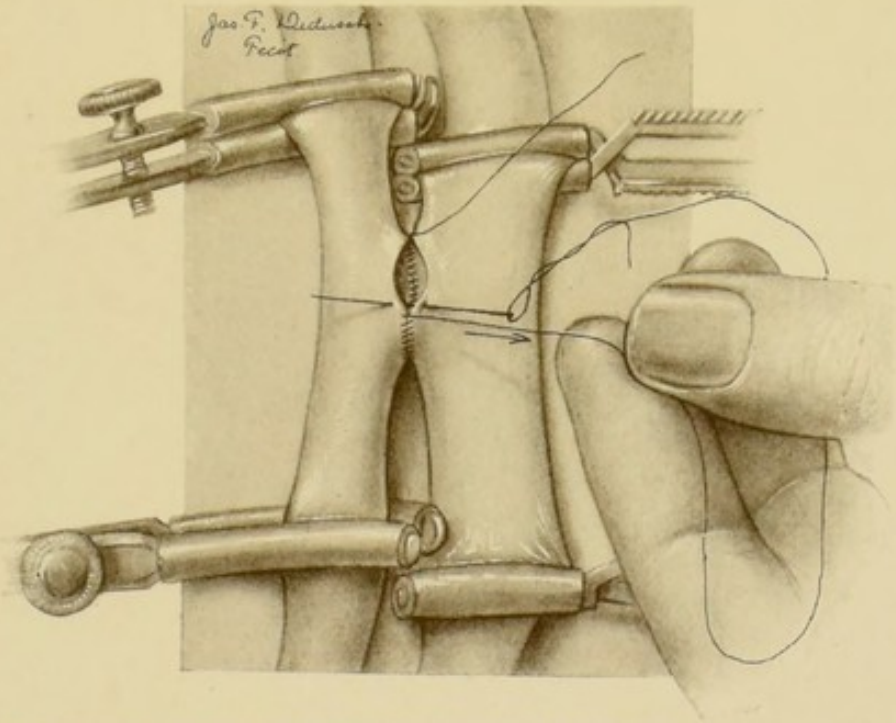

FIG. 39.—Posterior row of sutures completed; anterior row being placed. One continuous suture.

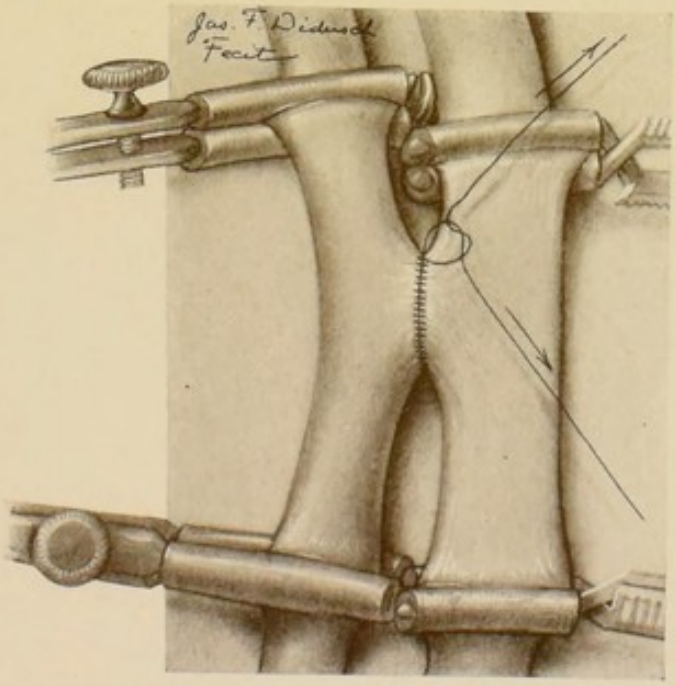

FIG. 40.—Suture completed and being tied to first knot—*outside* the lumen of both vessels.

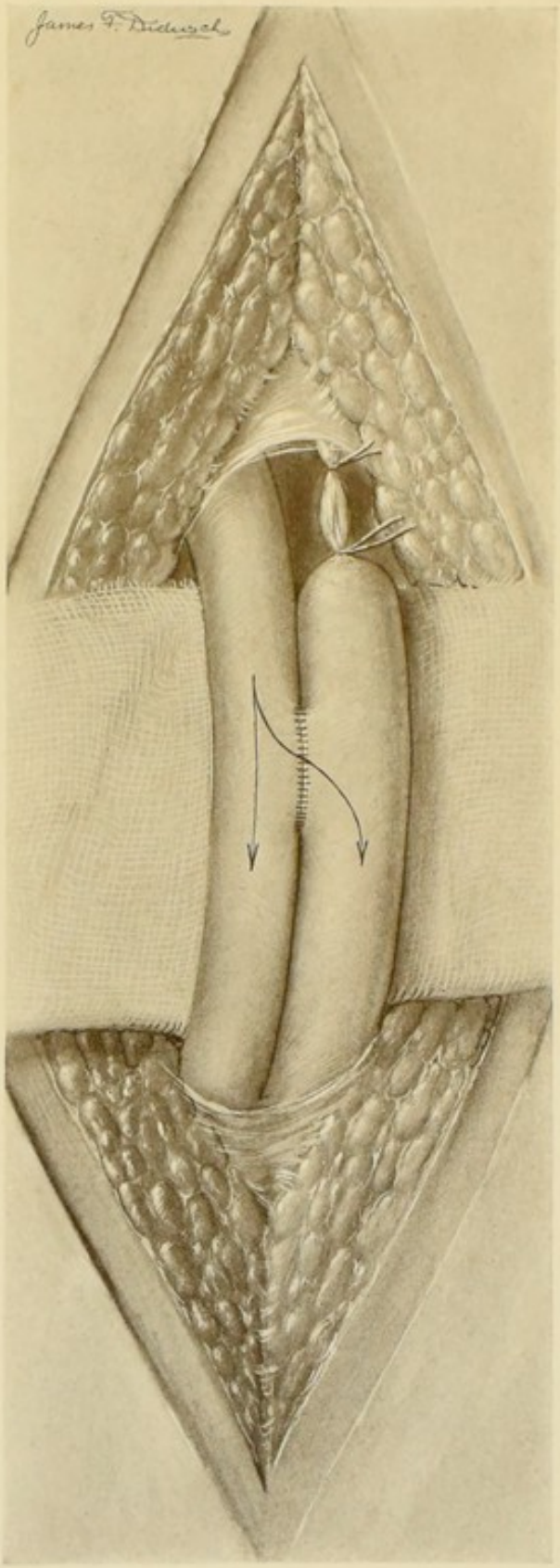

FIG. 41.—Clamps removed from vessels. *Proximal ligation* of vein. Blood is going down both artery and vein.

I think that this anastomosis, with a ligation of the vein on the cardiac side of the point of union, offers a much easier and safer method for reversal of the circulation than the present procedure of end-to-end anastomosis of artery and vein, with ligation of the proximal stump of the vein and the distal stump of the artery. When the latter method is used a failure of the anastomosis imperils the knee or elbow, owing to the complete division of the arterial trunk; and as a rule the disease process which leads one to do an arteriovenous anastomosis is not in itself so advanced as to threaten the larger joints. In the few experiments with the new method in which thrombi developed, they never obliterated the arterial lumen but were entirely lateral. Moreover, by this procedure the inflow of blood into a threatened extremity still has whatever arterial channels remain patent, and the venous trunk in addition may be utilized to carry some of the needed excess. It is important to ligate the vein above the anastomosis, to protect the heart from a direct back flow of blood under arterial pressure into its right chamber.

In brief conclusion, this method is presented because of its easy execution, making it superior to the longitudinal incision for experimental work, and because of its safety, making it better than the end-to-end for reversal of the circulation and other clinical conditions.

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CHAPTER V

Transplantation of a Segment of Vein or Artery

It sometimes occurs that the continuity of a vessel—interrupted by accident or operation—cannot be restored by simple end-to-end suture because of the length of the defect. In such instances, where it is either unwise or undesirable simply to ligate the ends of the vessels and drop them back, it becomes necessary to bridge the defect by transplanting a

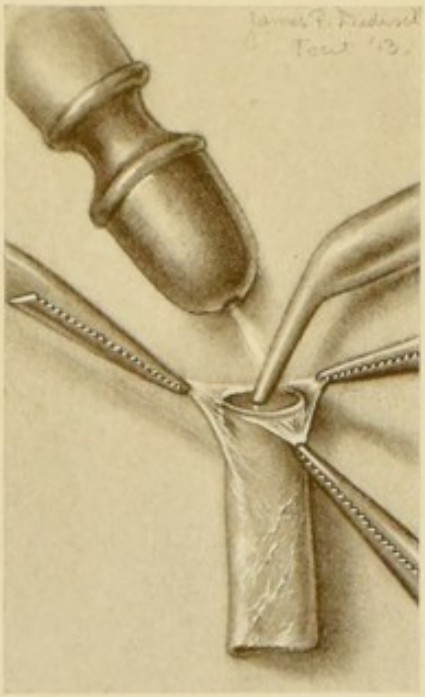

Fig. 42.—Washing out a venous transplant with liquid vaseline and salt solution.

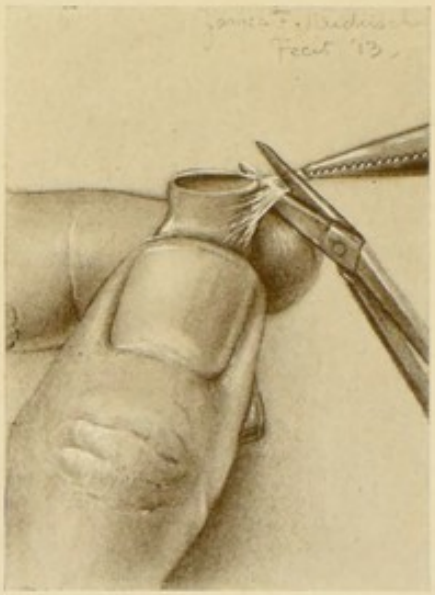

Fig. 43.—Cutting adventitia away from edges of venous transplant.

piece of artery or vein. The segment to be transplanted is best taken from another part of the body of the patient, although one removed from another individual will answer. Indeed, the recent work of Carrel tends to show that vessels, removed and properly prepared, can be kept in cold storage without deterioration for months before being subjected to

transplantation. It goes without saying that the transplant must be from the same species as the patient. The cold storage tissue is not at present practically available.

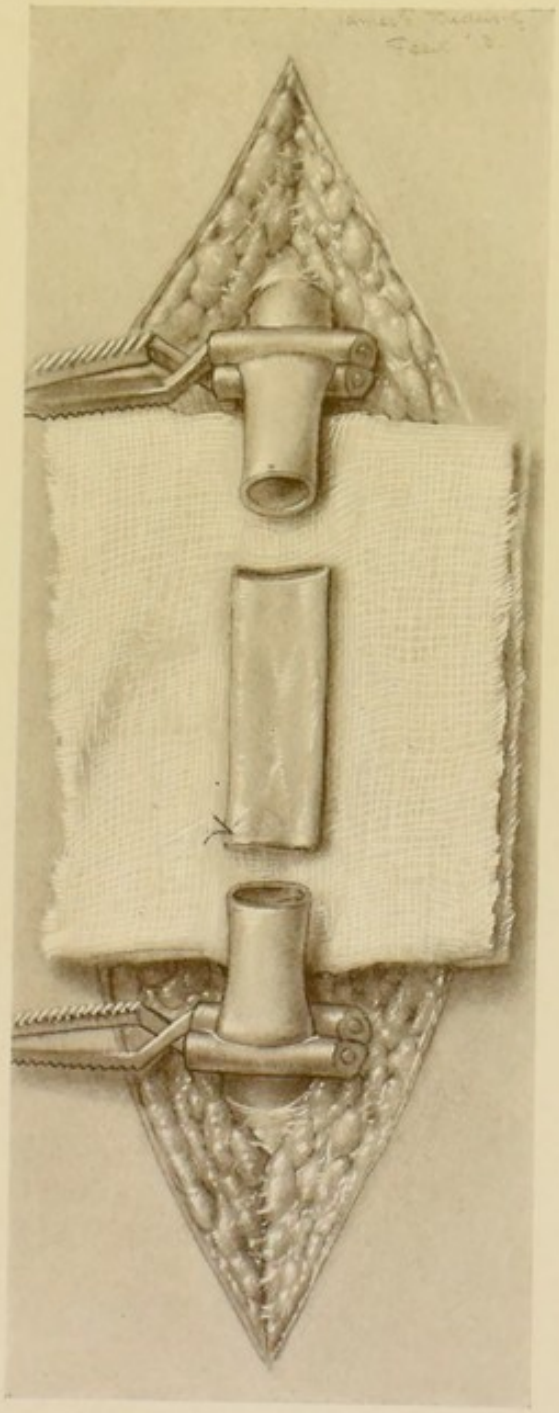

FIG. 44.—Measuring venous transplant between ends of artery.

While transplants, as stated above, may be either arterial or venous, they are in reality nearly always venous, because arteries cannot be spared from the body as can veins. For example, it would be unwise to say the least to remove a segment of the femoral or brachial artery of a patient—or one of his friends—to supply a defect in his popliteal

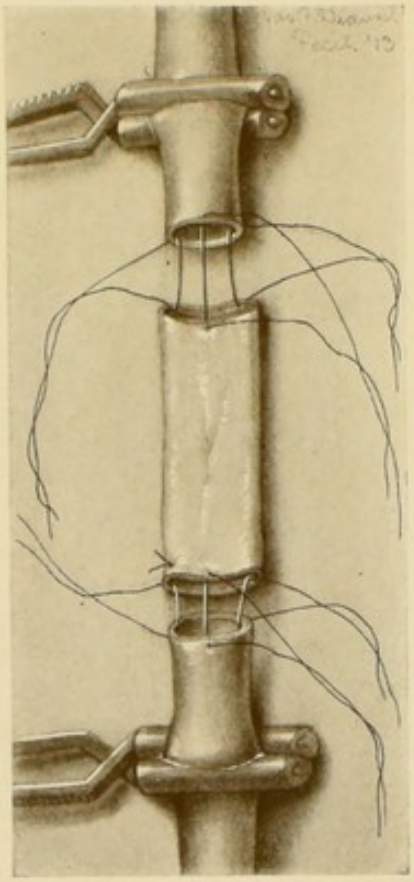

Fig. 45.—The transplant "set" by stay sutures placed at either end.

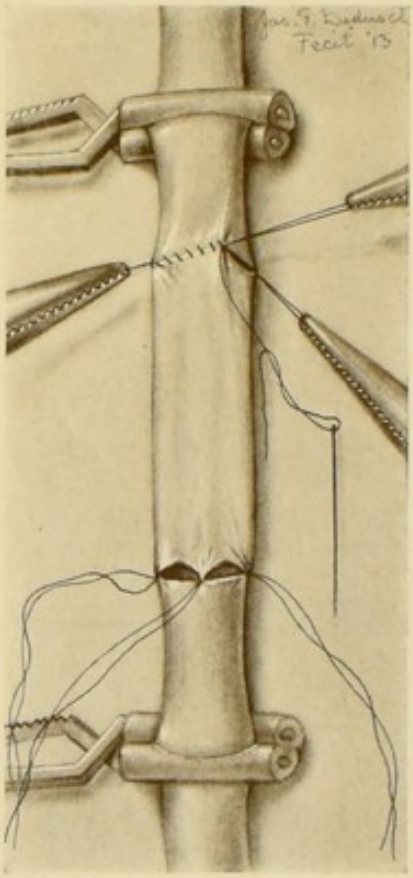

Fig. 46.—Suture in progress.

artery created by removal of an aneurism. However, he could well spare a piece of his internal saphenous vein, and as experiments have shown that a segment of vein interposed between two ends of an artery rapidly becomes able to withstand the arterial pressure by a hypertrophy of its walls, it is customary for purposes of transplantation to utilize a seg-

ment of the internal saphenous vein (Figs. 42 and 43) or some other easily accessible.

The operation is always accomplished by means of an end-to-end suture according to the method described in Chapter III. One or two additional suggestions, however, may be in order. In the first place a careful inspection of the lumen of the vein should always be made to ascertain the presence or absence of valves. This can nearly always be definitely determined by inspection of the intact vein before removing the segment, and it can also be determined after removal by injecting salt solution or liquid vaseline through the lumen. If valves are present the fluid will pass easily through the vessel in one direction, but going the opposite way it will be obstructed and the vein will bulge at the site of the valves. By taking this precaution one can "reverse" the vein segment, or in other words interpose it between the cut ends of the artery with the valves facing distally.

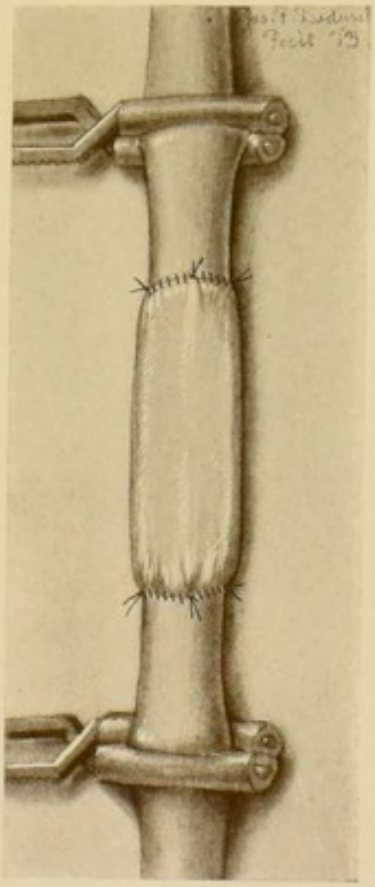

FIG. 47.—Suture complete; vein flaccid; clamps still on the artery.

Secondly, the segment must be the proper length. This is not so easily accomplished as it might seem, because the segment contracts (decreases in length) the moment it is removed, and expands (increases in length) almost to the normal as soon as it is transplanted and the blood flow started. Obviously, then, unless great care is exercised, the transplant will be so short that the delicate thread used in suturing will be unable to stand the tension necessary to "set" the ends, or it will be so long that when the blood goes

through, the segment will form a half curve, even an S, in the line of the parent artery. Generally speaking, the usual

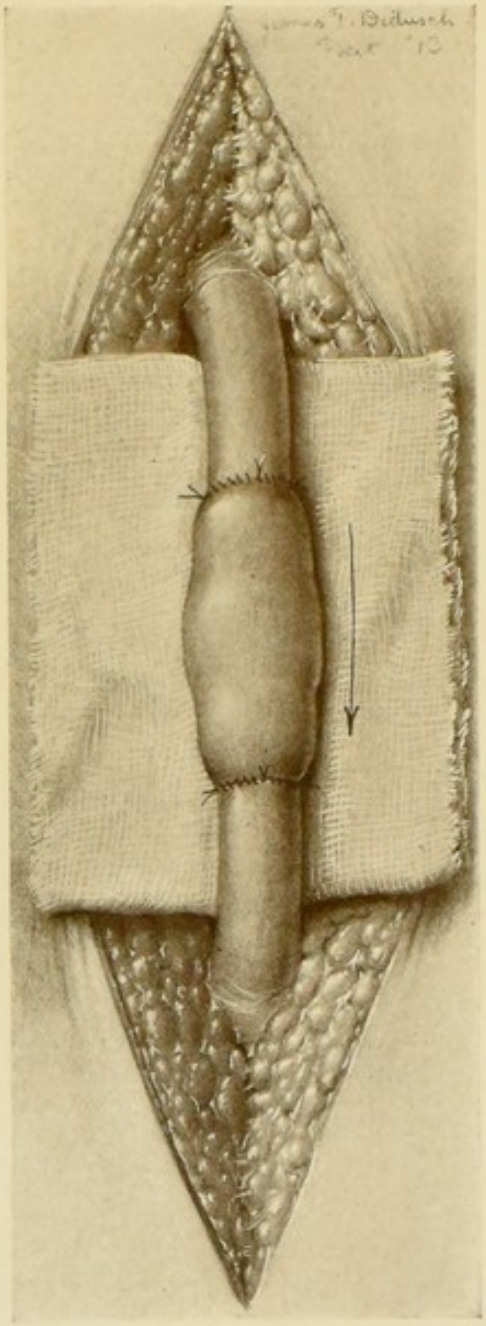

Fig. 48.—Blood going through the transplant. Vein bulged and tense from arterial pressure. Slight irregularity indicates situation of *reversed* valves.

procedure is to start out with a segment that is definitely too long and to trim it down with a pair of very sharp

scissors or preferably a sharp knife. A good working rule is to have the segment finally about one-quarter of an inch or even one-half inch shorter (Fig. 44) than the actual defect it is to fill.

Thirdly, it is always wise to attach both ends of the transplant to the parent vessel by means of the usual three stay sutures (Fig. 45), before beginning the actual suture of either end (Fig. 46). There will thus be less handling and consequently less danger of injury to the vessel.

As soon as both lines of suture are completed (Fig. 47), the segment transplanted is carefully wrapped in dry gauze and the blood flow gradually started by removing the distal clamp entirely, the proximal only partially. As the vessel is felt to bulge under the gauze, the fingers start a gentle massage-like motion over the suture lines, exerting a little pressure at the same time. If there is no alarming hemorrhage, the proximal clamp, previously loosened, is now entirely removed, and the massage-like motion and pressure are continued for about five minutes, after which there is a gradual cessation of the pressure and a careful removal of the encircling gauze (Figs. 48 and 49).

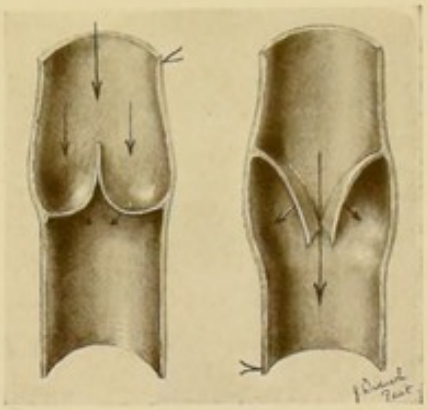

Fig. 49.—Valves of vein—diagram showing necessity for reversal in placing a venous transplant.

If the sutures have been carefully made and the above-mentioned details have been observed, there will be little need for any secondary stitches. They are, however, occasionally required in spite of all efforts, and are best placed as interrupted stitches during a temporary stoppage of the circulation, the gauze and pressure being reapplied as the flow is started.

When all bleeding has once been successfully controlled, it is most unlikely to recur if the proper care is exerted in closing the wound.

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CHAPTER VI

Arteriovenous Anastomosis—Reversal of the Circulation

Arteriovenous anastomosis or so-called reversal of the circulation [1] is an operation charily employed at present, but capable of great development for the relief of many conditions. To illustrate the use of the procedure, in the supposed case of an obstruction in an artery caused by a thrombus or growth, where it is inconvenient or impossible to make a complete arterial or venous transplant, after resection of the artery its *proximal* end can be united to the *distal* end of a severed vein. After extirpation of an aneurism or a growth involving the vessels, an arteriovenous anastomosis may be the most desirable operation to overcome the break in the circulation. In cases of threatened gangrene of the extremities resulting from obstruction of the arterial channel, this operation may be the only means of saving the limb.

The operation may be accomplished either by means of the end-to-end method of Carrel, or by a lateral suture. Since the union of the vessels for the relief of this condition is always made in Scarpa's triangle in the leg, and in or just below the axilla in the arm, the end-to-end method requires the vessels to be severed in regions which are usually far above the site of the obstruction. In the method of lateral anastomosis the artery, being undisturbed, is left to carry the blood as far as the obstruction, the burden of carrying it further being shifted to the vein. In other words the end-to-end method unnecessarily destroys entirely a channel that is only partially blocked, while the lateral method leaves it intact, simply adding another channel by means of which the blood may be carried as far as necessary. For

[1] First performed by San Martin y Satrustegui in 1902.

this reason those who have had most experience with this operation now exclusively employ the lateral method, unless, as happened in one of my cases, the artery is blocked almost throughout its entire course.

During recent years a number of attempts to reverse the circulation of a limb have been made, most of them ending in failure. In February, 1912, I collected and reported 52 cases myself, only 15, or 30 per cent. of the total number, being considered successful. The seemingly poor results in this field of work had previously given rise to a certain amount of scepticism as to the possibility of performance of this operation from a physiological standpoint, and had caused a discussion between Coenen of Breslau and Wieting[2] of Constantinople as to the efficacy of an arteriovenous anastomosis —reversal of the circulation—in preventing the spread of a real or threatened gangrene in the extremity of a human.

Coenen claims that Carrel's statements and experiments in regard to the possibility of reversing the circulation in a dog are not conclusive; that, in fact, the valves of the veins do not give way as Carrel asserts, and that as a result a true and complete reversal is never attained, the blood being simply shunted off to another vein and promptly returned to the heart without ever getting to the foot or hand. He further asserts that the procedure is both anatomically and physiologically wrong, and he therefore warns against the indiscriminate use of the operation.

Wieting, on the other hand, claims that in his hands the operation is clinically quite successful, although he admits that several questions, such as the return of the blood to the heart, are still unsettled. He is of the opinion that these

[2] This operation is known abroad as Wieting's operation. If it is to go by any man's name it should be that of San Martin y Satrustegui, who, as noted above, first performed the operation clinically. I prefer to call it reversal of the circulation.

doubtful points can be solved only through clinical experience, theories and experimental work not having given the required solution.

After his first utterance on the subject Coenen continued his experimental work and claims in later publications to have obtained additional evidence in support of his views, while Wieting continues to have a varying amount of success clinically with the operation.

I feel that there can be little doubt as to the correctness and truth of Carrel's assertion that complete reversal of the circulation is possible in the dog. Experienced, careful worker that he is, unexcelled as a technician, his articles must convince any unbiased reader, and his beautiful specimens, showing destruction of the vein valves by the arterial current, speak for themselves. Even Guthrie ("Blood Vessel Surgery," p. 161) admits the possibility of reversal in the limb of a dog, while denying this for the human, although his experience with the latter was *nil,* and his deductions entirely theoretical. My own animal experiments are in accordance with those of Carrel and Guthrie, and it is inexplicable to me why Coenen was unable to get similar experimental results.

Practically, in dealing with the human, the matter is somewhat different. Pathological considerations, such as arteriosclerosis, thrombo-angeitis obliterans, etc., give rise to complications not encountered in experimental work. The operation must not be attempted in the presence of these conditions, not only because the blood cannot be driven through a channel that is obstructed or obliterated, but also because vessels diseased, hardened, thickened, and roughened inside do not permit of a successful suture—a thrombus will invariably form at the line of suture because the endothelial lining of the vessel is abnormal or even at times lacking.

It is likewise a mistake to attempt to save a limb already lost, one that is so far advanced in the process of gangrene

as to put beyond question any hope of its rescue. These and other factors related to the subject I have tried to emphasize in articles written during the last four years. It is impossible to bring the dead back to life; it is a hopeless task to attempt the rejuvenation of sclerosed or thrombosed blood-vessels; yet this has all but been attempted, not once but many times. One has but to read the reports of the various cases to realize the absolute hopelessness of many of those chosen. It is little wonder that doubt arose as to the possibility of accomplishing this operation, which, by exercising proper care in selecting the case, and in the hands of an operator skilled in the suturing of blood-vessels, is an entirely feasible procedure.

Cases must be secured before actual gangrene arises—that is, in the stage of threatened gangrene. If gangrene has already set in, it is best to let the process subside or localize, and then to do the reversal in the hope of preventing further encroachments. The age of the patient has little or nothing to do with the question; the condition of his limb and the age and condition of his vessels are paramount in importance.

It must be remembered that senile gangrene is not the only form of gangrene. Certain cases of Raynaud's disease frequently progress to the stage of threatened or real gangrene, and occasionally an embolus lodging in an artery will give rise to most alarming circulatory disturbances, sometimes causing actual gangrene.[3] All such cases, properly selected, should be subjected to reversal of the circulation rather than amputation, an operation that is being gradually discarded by the modern surgeon.

I have reversed the circulation in the hope of preventing gangrene nine times, with six successes, one doubtful case,

[3] No case of diabetic gangrene has as yet presented itself for operation. I see no reason why the operation should not be done in this condition in suitable cases.

and two failures, amputation being required in the last two. There was no mortality, and in my opinion there is no reason for a greater mortality following this operation than after any other of equal severity. I hold this view notwithstanding the discouraging records of similar cases in the hands of other surgeons, who, I think, have met such ill success principally because their patients were so weakened at the time of operation that they could not withstand its shock,—just as they would have been unfit to withstand the shock of any other operative measure. Unfortunately, convalescence in a number of the recorded cases has been cut short by infection.

In answer to the contention of Coenen and his followers that the blood is unable to force the vein valves and that therefore it does not flow down the vein to any great extent, I wish to cite the case of one of my patients, a young woman now twenty-eight years of age, in whom I have successfully reversed the circulation of all four extremities to prevent both real and threatened gangrene and to relieve excruciating pain in a severe case of Raynaud's disease. In February, 1911, I performed an end-to-end anastomosis of the femoral artery and vein (in Scarpa's triangle) of the left leg, and in May of the same year a lateral anastomosis, according to the method of Bernheim and Stone,[4] of the femoral vessels of the right leg. Complete relief was obtained in the left limb, but the intervention of another surgeon ten days previous to my operation lessened the degree of success in the right. In the hope of avoiding the vascular operation in this leg, the sciatic nerve of the patient had been stretched—after which the pain not only was augmented but paræsthesia of the lower limb and a foot-drop occurred—conditions which the reversal which followed could not be expected to relieve. The circulation in this limb, however, was restored, and its general con-

[4] See chapter on Lateral Anastomosis.

dition has improved—but the pain has persisted, though lessened.

Early in 1912, the same condition—pain, actual and threatened gangrene—necessitated reversal of the circulation in both arms of this patient. This was successfully performed on January 23, 1912, in the left arm, and on March 5 of the same year in the right arm,—lateral anastomosis of the brachial artery and vein at the lower edge of the axilla being the operative procedure in each instance.

At the time of operation on the left arm, the little finger of that hand was partially gangrenous and amputation was postponed only in the hope that reversal might save it. I am happy to report that the circulation improved in that finger immediately after the operation and remained so good that a slough formed and the finger healed perfectly within a short time thereafter.

The patient has been relieved of all symptoms in all extremities except the right leg, where the lack of complete success has been explained. She is now active and able to attend to her duties. A definite pulsation can be felt at the sites of all four anastomoses and can be followed down the veins of both arms well below the elbows. Indeed, pulsation can even be seen in the veins of the arms. In the legs pulsation can only be *felt* a few inches below each fistula, but this is due to the great thickness of the tissues overlying the vessels in the lower extremities. In addition to the palpable pulsation, there is a definite thrill at the site of each anastomosis which is easily felt. It can be followed down the lower extremities with the fingers only an inch or so, because of the thickness of the overlying tissues, but in the arms it is beautifully traced to and below the elbow. With the stethoscope these thrills are heard to be quite powerful,—humming-top in character. In the lower extremities they can be traced down into the popliteal spaces, in the arms to both wrists.

The patient was shown before The Interurban Orthopedic

Club which met at the Johns Hopkins Hospital, November 18 and 19, 1912. At that time, in addition to being examined by the members of the club, she was examined by Dr. W. S. Halsted and Dr. John M. T. Finney, all of whom agreed that the blood was definitely going *down* the veins. The case has also been passed upon by Dr. Joseph C. Bloodgood, in whose clinic at St. Agnes' Hospital and by whose courtesy I was privileged to do the operations.

I have given a detailed account of this case because it is the only existing record of successful reversal of the circulation in all four extremities of the same individual, and I offer it as incontrovertible substantiation for upholding this operation.

I summarize herewith the necessary precautions to be observed before proceeding to operation in a case of this sort:

1. Select the cases with utmost care, (*a*) ruling out those in which a fulminating gangrene is present; (*b*) ruling out, or postponing until the condition is improved, those in which the patient is so debilitated as to be unable to withstand any operative procedure; (*c*) ruling out those in which the vessels (artery and vein) are evidently obstructed or markedly sclerosed.

2. If there is any doubt about any case, cut down upon and expose the vessels; then, if they are suitable for anastomosis, the operation can proceed; if not, it is best to resort immediately to amputation.

3. Last and most important, the operator must be a man of experience and good judgment in vascular surgery.

I conclude this chapter with emphasis of the fact that relief from pain cannot always be relied upon to follow immediately after operation. Sometimes it does, but in other cases it is withheld for days, sometimes weeks. Anodynes should be freely given. The limb should be kept in a plaster cast for three weeks. At the end of the first week it should

be removed for the taking out of skin stitches and for an examination by stethoscope of the anastomosis. If at this time a thrill can be heard and the gangrene is checked or averted, the operator is justified in anticipating success. The absence of the thrill, however, at this time need not be interpreted as an indication of failure, unless the gangrenous condition has becme aggravated.

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CHAPTER VII

Varicose Veins

Varicose veins are usually seen in the lower extremities in adults, although they may occur in any part of the body. Many causes have been assigned to this condition—obstruction to the venous return from pregnancy, tumor of the pelvis or some other form of pressure, cardiac weakness, congenital venous defect, etc.,—but whatever may be its origin in a given case there is a gradual but progressive valve failure in the superficial veins, amounting in the last analysis to complete destruction and insufficiency. Once this condition has arisen, it can be cured only by operation, although the symptoms can be frequently relieved to a greater or lesser extent by baths, change of occupation, pressure bandage, and a number of other well-known measures.

The operation of Schede, and its modifications, and that of Trendelenburg and its modifications, have been widely employed and have been followed by varying measures of success. The first consists in a division by partial or complete circular incision in the upper third of the leg of all the superficial veins, including the long and short saphenous, down to the deep aponeurosis. Two such incisions may be made, or there may be one spiral incision circling the leg two or three times, according to the various modifications, all of which have for their purpose the division of the superficial veins of the limb at different levels.

Trendelenburg's operation, consisting of division and ligation of the long saphenous at the point of junction of the lower and middle thirds of the thigh, was subsequently modified by its author by ligating the saphenous in two additional places—just above the internal condyle and just below

the knee. The vessel is exposed through small incisions at right angles to its course and ligated between two ligatures, each end being doubly ligated. The operation is usually performed under local anæsthesia.

Better than either Schede's or Trendelenburg's operation is the method of resecting the offending veins. This may be either partial or complete, and is best accomplished by two incisions—one extending from the upper end of the saphenous vein down to the upper limits of the knee, the other extending from the lower limits of the knee down to the ankle, or as far as the varices extend. It is necessary to interrupt the incision at the knee in order to avoid scar formation, which is frequently painful and might cause unnecessary functional disturbance of the joint. The vein at the knee is easily removed subcutaneously by working down from the upper incision and up from the lower incision. If all varices cannot be removed by making the two cardinal incisions, as outlined, additional incisions must be resorted to. The operation is rather a formidable one, but the results justify its use in practically all cases where operation is indicated.

The subcutaneous method of removing varicose veins—by means of a vein enucleator—as suggested by C. H. Mayo in 1906 has not stood the test of time and need only be mentioned in passing.

In 1906 Delbet suggested and carried out an operation, saphenofemoral anastomosis, by which he proposed to relieve a certain group of varices by reimplantation of the saphenous vein, the valves of which have become incompetent, into the femoral vein at a site 10 or 12 cm. lower than the original and normal junction and below one or more sets of competent valves. Delbet reported eight cases, and at the German Surgical Society in 1911, Hesse and Schaack brought the number of cases up to forty-eight, one death from infection

having occurred in their own series of twenty-three cases, the other twenty-two being considered cured, although sufficient time had hardly elapsed to permit of any such determination.

It is not my intention to give the details of this operation nor to discuss its theoretical possibilities. Those interested may refer to the original papers, references to which are appended. I do, however, wish to go on record as unqualifiedly condemning this operation as a pernicious use of the blood-vessel suture. It is dangerous, in that it converts a condition that in the great majority of cases can be relieved by simple and practically harmless measures into one that requires for its relief a most delicate major operation, one that in unskilled hands will most certainly be followed by dire consequences. So far as I am aware the operation has not been practised in this country.

Simple ligation, excision, partial or complete—these are measures practically devoid of danger, and as the condition itself is in the majority of cases more annoying than serious, it seems unnecessary and unwise to employ a difficult and dangerous operation where other far simpler means offer relief.

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CHAPTER VIII

Surgery of the Heart

Surgery of the heart consists chiefly in attempting to suture bullet and stab wounds, accidental or self-inflicted, although there is an increasing number of recorded cases of pericardiotomy—drainage of the pericardium—and of cardiolysis—resection of the ribs overlying an adherent pericardium.

Coincident with the advance of surgical technic, there has been a gratifying increase in the self-confidence of the modern surgeon, so that those individuals unfortunate enough to receive an injury to the heart now have a pretty fair chance for life—provided they live long enough to be brought to a well-equipped hospital. The usual method in such a case, a proper diagnosis having been made, or, when this is impossible, signs and symptoms sufficient to warrant exploration having been obtained, is hurriedly but freely to expose the heart either by resecting the two or three ribs overlying it or by making a trap-door exposure. If the pleura has not been wounded it should be displaced outward. The pericardium is opened by a longitudinal incision, the heart is grasped by the left hand and lifted out, the tip of a finger being placed over any wound that may be encountered in order to control bleeding. With a large, round, curved needle, threaded with catgut (silk, too, may be used), the wound is closed either by a simple through-and-through continuous stitch or by several interrupted stitches, after which, all blood having been removed from the pericardial cavity, the heart is carefully replaced in its bed.

In a paper on "Experimental Surgery of the Mitral Valve," written in 1909, I remarked that it seemed to me more conservative never to close completely the pericardium

after it had been opened to suture a wound of the heart. A small opening left at the most dependant part of the incision would take care of any little ooze or leakage that might occur, which in a closed sac might seriously embarrass the heart action. I still hold to this opinion to the extent of advising that its adoption as a rule might in the great majority of instances obviate the necessity of inserting a drain in the pericardium; any collection of fluid, pus, serum, or blood would be forced out into the pleural cavity or, if this is intact, into the tissues beneath the incision, where signs of its presence would soon be given.

In cases where the patient is exsanguinated and in collapse, an intravenous infusion of warm salt solution should be started while the preparations for operation are in progress. As a last resort direct transfusion of blood may be given either during the course of the operation or immediately upon its conclusion.

It is probable that many unsuccessful attempts to suture heart wounds are never reported; therefore any statistics that may be given must not be accepted too literally. Rehn in 1907 collected and reported 124 cases with 49 recoveries (39.5 per cent.) and 75 deaths (60.5 per cent.). Of the 75 fatalities, 16 died on the operating table, 17 died from loss of blood and collapse within two days, 30 died of infection—purulent pericarditis and empyema. In many cases the urgency of the case prevented disinfection of the field—a difficulty that the iodine technic should overcome in future cases. One patient (Gerzen's) died of sudden hemorrhage on the fifty-third day.

Statistics later than those of Rehn's are those reported by Hesse, who gives 219 cases with 103 recoveries (47 per cent.) and 106 deaths (53 per cent.), and of Simon, who reports 241 cases with 117 recoveries (49 per cent.) and 124

deaths (51 per cent.). It will thus be seen that the number of cases saved is gratifyingly large.

Cardiolysis is an operation that was introduced in 1902 by Brauer of Heidelberg for the relief of adherent pericardium. It consists of a subperiosteal resection of the precordial ribs, to the under surface of which the pericardium is adherent. A number of successful cases have been reported not only by Brauer but by others, and this simple method of treatment promises to revolutionize the therapy of adherent pericardium.

According to Hirschfelder, "As regards the indications for cardiolysis, it would appear that since the adherent pericardium cannot otherwise be relieved, this operation is worthy of trial whenever symptoms of cardiac weakness occur and recur in a patient with well-marked adhesions to chest wall (tugging in of the lower ribs, fixation of the left border of flatness on inspiration, immobility of the apex) and recur in spite of general cardiac hygiene."

Pericardiotomy is an operation in which the pericardium is freely opened and drained, and is most frequently resorted to for purulent effusions, although it may be required to relieve a simple serous hæmo- or pneumopericardium. Exposure of the pericardium is usually obtained by resecting close to the sternum the fourth, fifth, and sixth costal cartilages; sometimes a satisfactory exposure will be obtained by resecting only one costal cartilage, while in other instances two or even all three will have to be removed. The chief dangers are wounding of the internal mammary artery and entering the pleural cavity, accidents that can be avoided by careful work in the vast majority of cases. The opened pericardium should be thoroughly irrigated with warm salt solution, the operation being performed under light anæsthesia. A soft rubber tube or protective wick should be left

to drain the pericardium and the whole wound should remain open in order that further irrigation may be instituted should necessity arise.

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CHAPTER IX

Aneurisms

There are several different methods of dealing with aneurisms, speaking generally, and I shall take up, in detail, those that have given the best results. Before opening the subject, I wish to call the attention of the reader to the fact that, due to anatomical conditions, in certain regions of the body there is little or no choice of operation; in others, there is a very wide choice, and the success or failure of the procedure may depend on the type of operation selected. For example, aneurisms involving the arch of the aorta lend themselves to practically but one form of surgical interference—wiring—while those involving the popliteal artery may be treated by any one of several different methods—simple ligation, endo-aneurismorrhaphy, excision, extirpation and arterial suture, etc. Aneurisms of the abdominal aorta are usually best handled by wiring, especially those occurring above the renal vessels, but Halsted's aluminum band has been successfully applied, and actual ligation of the aorta has been performed. Arterial suture may possibly be of service here provided the aneurism is of such size and position that it can be excised. It is a question as to whether Matas's endo-aneurismorrhaphy will ever be successfully applied to the aorta, although it should always be kept in mind. On the other hand there is little or no choice when it comes to handling aneurisms involving the great vessels at the root of the neck. Halsted's band has a certain usefulness, and it is possible that Matas's operation may be of limited service, but in the great majority of cases simple ligation is the only measure that offers the slightest hope of success, and this is

often as difficult and delicate and dangerous a piece of work as falls to the lot of the surgeon.

It is unnecessary to devote a special section to the method of extirpating an aneurism or of ligating an artery. The application of general surgical principles is all that is required, care being exercised to obtain a proper exposure. In the tying of all vessels, two ligatures are commonly used; these should be separated by an interval of from a quarter to half an inch. Both ligatures should be of heavy material so as to minimize as much as possible the liability of cutting through the vessel wall and consequent hemorrhage. Kangaroo tendon is an excellent material—it is heavy, strong and has the very slight degree of elasticity that is greatly to be desired.

The following methods, then, of dealing with aneurisms will be described: (1) Matas's endo-aneurismorrhaphy; (2) the Moore-Corradi wiring operation; (3) Halsted's method of gradual occlusion.

ENDO-ANEURISMORRHAPHY (MATAS)

This operation—commonly known as the "Matas operation"—was first practised by its author on March 30, 1888, the patient being a man who was suffering from an aneurism of the brachial artery that had resisted proximal and distal ligature. Success crowned Matas's effort, and the operation as it has been developed has come to be one that can be relied upon to give constant results in a class of cases which formerly tried the patience and resources of both patient and surgeon, and not infrequently ended in the crippling or destruction of the former.

The method comprises two separate and distinct forms of operation, the choice of one of these being entirely dependent on the type of aneurism under consideration. The first

and most widely used form, the obliterative endo-aneurismorrhaphy, is used "in those aneurisms in which the parent artery is entirely lost at the site of the aneurism by expanding into the aneurismal sac throughout its circumference; also those in which the friability or diseased state of the sac wall is such as to preclude all possible use as plastic material (atheroma, calcareous degeneration). In these cases there are always two orifices within the sac separated by variable intervals, and there is no visible outline of the main artery in the interior of the sac. Except in unusual conditions no attempt is made to restore the continuity of the parent artery; the blood stream is interrupted in that part of the vessel which directly opens into the sac, and the arterial orifices are simply closed by suture, thus shutting off the sac cavity from all visible sources of blood supply."

The second form, the restorative or reconstructive endo-aneurismorrhaphy, has a more limited field of usefulness in that it is only indicated in definite saccular aneurisms, or those in which there is a "well-defined and deep furrow or gutter leading from the inlet to the outlet of the sac. This deep groove or fissure furnishes the outline of the parent artery, which is easily restored without obliterating the main channel."

In the obliterative type of operation, after all pulsation and bleeding into the sac has been absolutely controlled by temporary ligatures or the application of Crile clamps to the vessels outside the aneurism, a longitudinal incision is made through the wall of the sac, so as thoroughly to expose all visible orifices within it. If any loosely adherent clots are present, as they usually are, they should be carefully wiped out, after which all orifices are closed (Fig. 50) by rather deep interrupted or continuous sutures of chromic catgut, No. 1, 2 or 3, according to the size of the aneurism,

threaded on half or full-curved round needles. The cavity of the sac is then totally obliterated by rows of sutures placed in its walls. This is occasionally difficult to accomplish because of the frequent large size of the cavity, the thickness of the sac wall, and the general density of the surrounding tissues, but by taking advantage of the natural

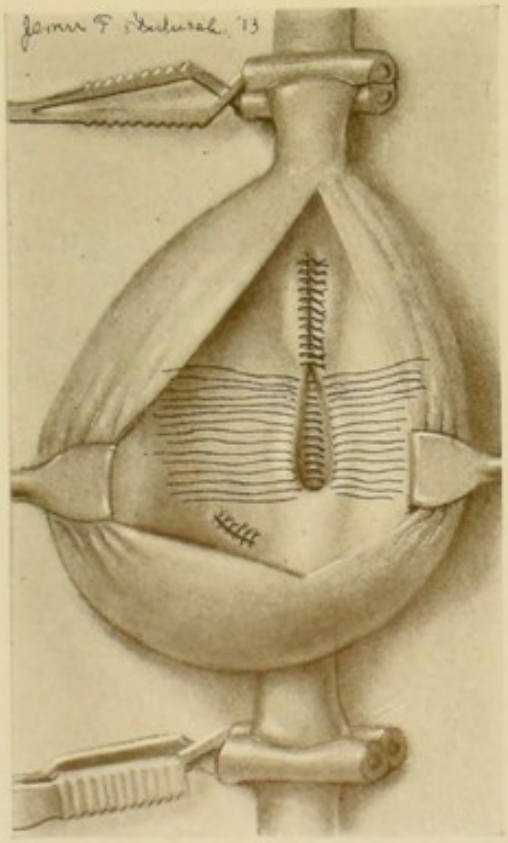

Fig. 50.—Obliterative endo-aneurismorrhaphy (Matas). Orifices in aneurismal sac being obliterated by suture, when restoration or reconstruction of arterial channel is impracticable. (Keen's Surgery, vol. v.)

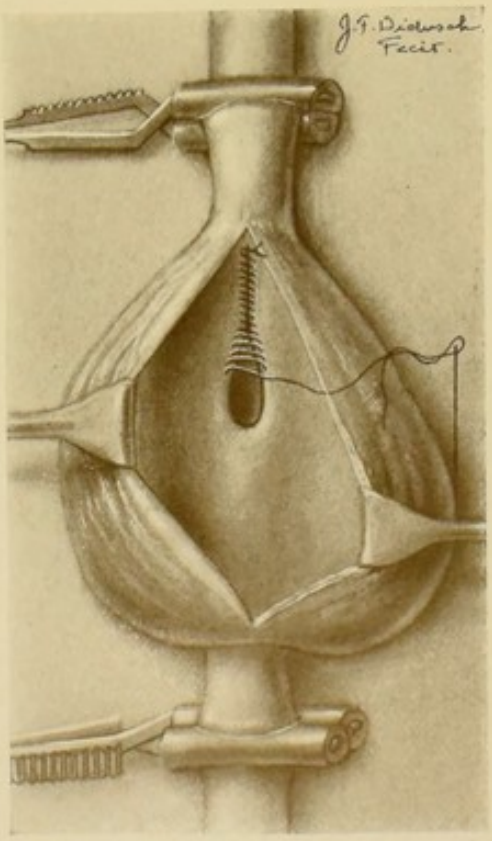

Fig. 51.—Restorative endo-aneurismorrhaphy (Matas) applied to sacculated aneurisms with a single orifice of communication. Orifice being closed by continuous suture, without obliterating parent artery. (Keen's Surgery, vol. v.)

folds in the sac wall and by the exercise of a bit of ingenuity, it can nearly always be accomplished without infolding sliding skin flaps, a method to which one must resort very occasionally. Emphasis is laid upon this point because it is always unwise to drain an unruptured, uninfected aneurismal cavity. In those that are ruptured or infected at the

time of operation, drainage and healing by granulation should be the method of choice, rather than any attempt to obliterate the cavity.

In the restorative or reconstructive form of endo-aneurismorrhaphy, after opening the sac an attempt is made to close off the parent artery (Fig. 51) from the sac without obliterating the lumen of the artery (Fig. 52). Where the aneurism is of the purely saccular variety, and there is only one small opening into the side of the artery, it is a rather simple affair to close this off by interrupted or continuous sutures of No. 0 to 00 chromic catgut threaded on small curved needles.

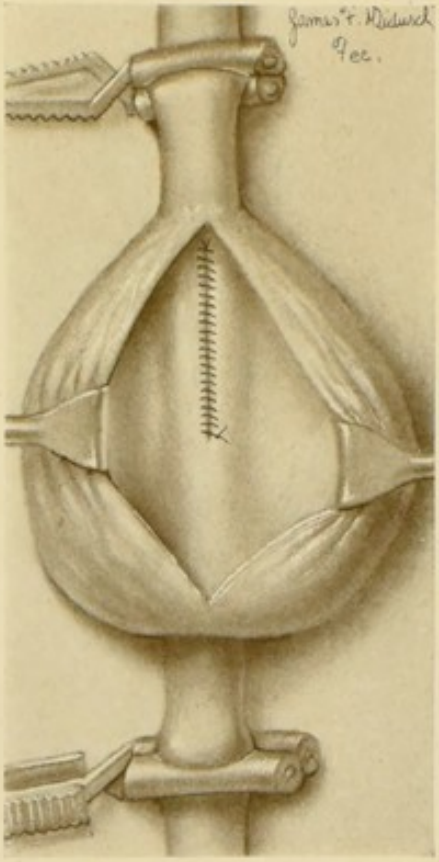

Fig. 52. — Restorative endo-aneurismorrhaphy (Matas). Aneurismal sac closed off from parent artery. (Keen's Surgery, vol. v.)

But where a furrow running through the floor of the aneurism is all that remains of the parent artery, conditions are altered and it is a difficult matter to reconstruct the vessel. The use of a catheter, placed in the bed of the vessel, as a guide in suturing facilitates matters, but it would seem best in cases where there is extreme need for the preservation of circulation through the main channel to perform an arterial or venous transplantation after complete excision of the aneurism.

After restoration or reconstruction of the artery the cavity of the sac is obliterated in the usual way, great care being used to make it complete and absolute.

The chief advantages of the Matas operation over other forms are:

(1) The collateral circulation of the extremity is left practically undisturbed.

(2) There is very little danger of injuring the parent vein—a real danger in extirpation and one markedly increasing the danger of gangrene.

(3) The parent artery is obliterated over the least possible extent.

Statistically Matas reported in 1908 the following:[1]

85 cases operated by 52 surgeons
59 were of the obliterative type (69 per cent.)
26 were of the restorative or reconstructive type (30.8 per cent.)

Recoveries	78
Deaths	7
Gangrene	4
Relapses	4
All reconstructive cases	
Secondary hemorrhage	2

WIRING

This operation, which is only indicated in certain forms of thoracic and abdominal aneurisms otherwise necessarily inoperable, was devised in 1864 by Moore, of London, and subsequently modified by Corradi, the procedure being at present known as the Moore-Corradi method of wiring aneurisms.

According to Dr. John M. T. Finney, who has probably had a wider experience with this method of treating aneurisms than any one else in this country, all that is necessary as regards technic is a hollow needle not too large in size, insulated with the best quality of French lacquer to within a short distance of its point. Through this a wire made from a silver and copper alloy (Hunner) in the proportion of 75 parts copper to 1000 parts silver is passed.

[1] For detailed statistics see Keen's Surgery, vol. v, pp. 279 and 280.

The wire should be previously wound tightly upon a wooden spool in order to give it a coil, and care should be taken to avoid kinking, as this interferes with its passage through the needle.

After the skin has been cocainized (supposing a thoracic aneurism is to be treated) and drawn to one side, the needle is inserted slowly until the arterial blood appears in jets through its lumen. The end of the wire which has been previously passed into the needle, but not so far as the point, is now passed directly into the aneurism until the amount wound upon the spool has been introduced into the aneurismal cavity. This amount is arbitrarily chosen to be ten feet. Freeman and some others hold the opinion that the greater the amount of wire introduced into the sac the better, but the prevailing objection to this view is that it prevents the contraction of the resulting clot in the course of its subsequent organization.

If the needle is not well insulated, or if it is pushed so far into the aneurismal sac that its non-insulated shoulder comes in contact with the skin, there is danger that an electrolytic burn may result along the needle's track. The consequent slough decreases the strength of the aneurismal wall and is likely to cause leaking at that point. Hare, who also has had considerable experience with the wiring operation, calls particular attention to the necessity for care in this detail.

With the positive pole attached to the wire and the negative pole at the patient's back, the current is gradually turned on, the routine being 10 milliamperes for the first ten minutes, 20 ma. for the second ten minutes, 30 ma. for the third ten minutes, and so on until about 70 or 80 ma. have been attained; then the current is reduced by the same succession of intervals by which it was advanced, the whole procedure lasting from one to one and a half or even two

hours. After the current has been passed through the aneurism for the given time, the needle should be carefully withdrawn with a slight rotary motion, not disturbing the wire, which is, of course, left in the sac. When the needle is entirely withdrawn the wire is cut as short as possible, depressing the skin with the point of the blunt scissors. The skin should then be pinched up with the fingers, until the end of the wire is completely buried beneath its entire thickness, and if the precaution of drawing the skin to one side before insertion of the needle has been taken, as suggested, the end of the wire will not remain opposite the skin puncture. This seems a small point, but it is important in order to prevent a certain amount of irritation and the possibility of infection extending down along the course of the wire. Pressure over the wound should be applied immediately upon the withdrawal of the needle, in order to prevent the formation of a hæmatoma due to the escape of blood into the subcutaneous tissue.

In the case of aneurisms of the abdominal aorta, it is of course necessary to open the abdomen and expose the aneurismal sac, at least in part, before insertion of the needle. For the manipulations within the peritoneal cavity, it is usually necessary to give a few whiffs of ether, but the patient is allowed to come out of the anæsthesia and remain conscious during the entire time that the current is running, the abdominal contents being packed off so as to allow the needle to protrude. Ether may again be necessary in closing the peritoneum, but if morphine has been judiciously used very little will be required.

The immediate risks of the operation, especially in aneurism of the thoracic aorta, are not great. They consist in the possibility of an end or loop of the wire sliding along the wall of the aorta in the direction of the heart and interfering with the action of its valves (its presence in the aorta

giving rise to no symptoms), or in the formation of emboli which may be swept off by the blood current. These complications have occurred only in rare instances. In a case treated by Pasham a loop of wire entered the cavity of the heart without fatal result, the condition being found accidentally at autopsy some time after wiring. In another instance an embolus necessitated amputation of an arm, but since the patient's aneurism was cured he was content, saying "that he would rather have one arm and no aneurism than two arms with an aneurism."

The remote risks arise from emboli or sloughing due to a too strong current, sepsis, and from rupture of the aneurismal wall, due to the shunting of the blood current by the new-formed clot against another portion of the aneurismal sac. With the possible exception of the last-mentioned risk, others in this advanced day are apparently negligible.

The immediate benefits of this operation are most striking. Perhaps the most remarkable of all is the diminution of pain, which often begins before the operation is finished. In a number of instances, the patient while still on the operating table has stated that the pain was appreciably decreasing. From this encouraging result one is justified in promising the patient a marked relief from pain, even if no other benefit is derived; and frequently one can guarantee a diminution of the dyspnœa, sometimes so pronounced in advanced cases.

As a rule the hardening of the clot as shown by the lessening or disappearance of expansile pulsation does not take place for some days or even weeks, but immediate marked diminution in the pulsation of the tumor has been observed in a number of cases. Complete rest in bed for a term of weeks or even months after the wiring is an absolute necessity for the success of the procedure, and it is often difficult to restrain the patient who feels so well two or three weeks after

the operation. Hirschfelder especially lays emphasis on the need for bodily and mental rest, and suggests that the administration of calcium salts both before and after the operation might be of advantage. He further says that, " . . . the treatment (preliminary and post-operative) is quite as important as the operation itself. In justice to both himself and the patient, the surgeon should, before undertaking the case, insist that the patient consent to remain under treatment and absolute rest for from three to five months, at least a month of which should precede the operation, and at least another month should elapse after the last trace of expansile pulsation has been felt in the tumor. Only threatened rupture of the aneurism or intolerable symptoms justify an operation without prolonged preliminary treatment."

Finney[2] reported twenty-three personal cases, of which only two were alive at the time of the report, one nearly three years, the other not quite one year after the operation. All patients were men, mostly young men, only two being over fifty years of age. One-half gave a history of lues, and one, who denied it, had a positive Wassermann. Over 25 per cent. admitted the excessive use of alcohol. In three instances the trouble was apparently of traumatic origin.

There is little to be hoped for in the way of permanent cure by this operation. The condition is always desperate and with few exceptions absolutely hopeless from the outset. But when one takes into consideration the prompt, almost constant, marvellous relief from that terrific pain so uniformly suffered by individuals afflicted with aortic aneurism, the almost certain prolongation of life—frequently extending over months and years, during which time the patient is up and about—and the utter hopelessness for the patient under

[2] Since his original report, Dr. Finney has wired an additional number of cases, the results of which have been extremely gratifying.

any other form of treatment, it is evident that wiring is a justifiable operation in every case of abdominal and thoracic aneurism where it is not especially contraindicated.

GRADUAL OCCLUSION OF VESSELS BY MEANS OF HALSTED'S METAL BANDS

It has been a recognized fact for years that if the parent vessel of an aneurism could be occluded by some process slow enough to permit a concomitant development of satisfactory collaterals, a great step forward in the treatment of this condition would have been taken. Many surgeons have worked on the subject, always a fascinating one, and numerous methods have been suggested and tried out, only to be discarded later on as worthless. The method devised by Professor Halsted in 1905, and practised since then by him and others, has stood the test of time and has proved to be of undoubted value in certain forms of aneurism. It consists, in brief, in partially constricting the vessel by means of an aluminum band rolled around the vessel by means of an instrument specially constructed for that purpose, the idea being that, "When the lumen had been, perhaps, not quite occluded, complete obliteration might result spontaneously with the conversion of the arterial wall embraced by the band into a solid cylinder of living tissue. This may be considered the ideal closure of an artery."

The aluminum used varies in thickness from No. 25 to No. 46 (American scale), the finer numbers being used on small vessels, the heavier on larger ones like the aorta. For the common carotid of the human, No. 33 does very well, while perhaps No. 35 or No. 36 would be better for the aorta. Coming as it does in sheets, the metal is cut in strips to fit the band roller, the length of the strip being about that of the circumference of the full artery, the width varying accordingly, being about 1 cm. for the thoracic aorta and innominate

artery in man. The distal end must be rounded and "manicured" with a nail file to facilitate coiling; the edges are simply smoothed and the proximal end is left square. If these precautions are taken and the aluminum sterilized only once—repeated boilings render it too brittle for perfect rolling—there is practically no danger of a vessel cutting itself on the band, unless it is markedly sclerosed and brittle—in which case the band had best not be used at all.

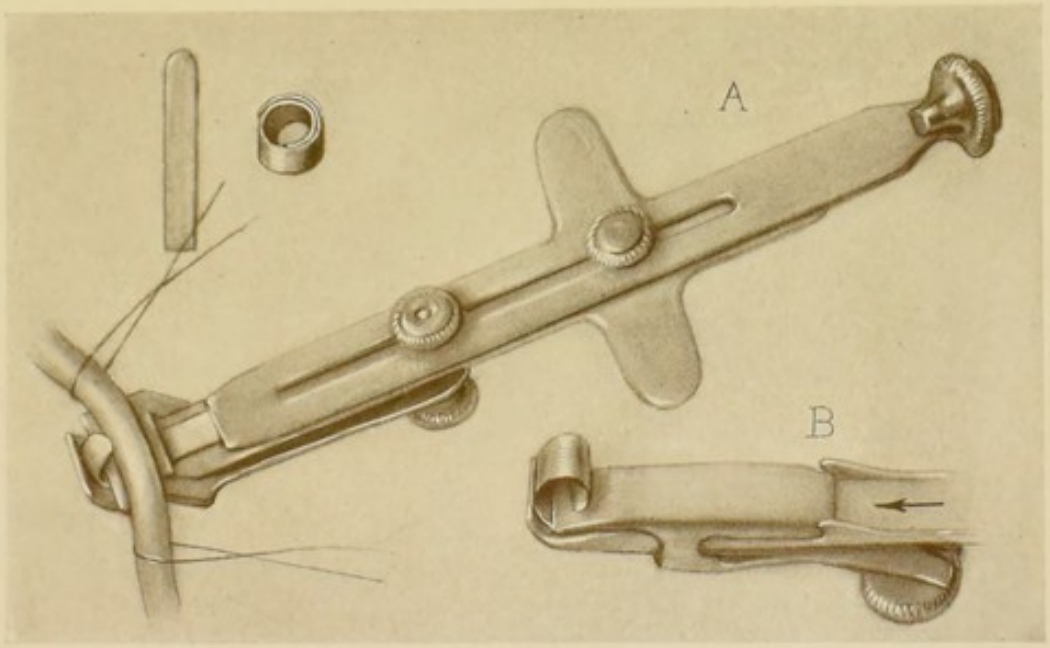

FIG. 53.—*A*, Halsted's original band roller in the act of curling a metal strip about an artery; *B*, the improved band roller about to expel a band.

The band roller is so beautifully illustrated that a detailed description is superfluous (Fig. 53, *A* and *B*). It is enough to say that the band, all properly cut and manicured, is "loaded" into the instrument and is curled around the artery by means of a piston or driving-rod, the instrument being gradually withdrawn as the curling proceeds. "The band should be long enough to encircle the artery in its expanded state and the metal should be sufficiently thick and wide to sustain the curl given it by the instrument. If perfectly

rolled, the inside and outside circles of the metal (there are usually about one and one-half or two circles) touch each other at all points of the surfaces of contact and, in consequence, the cohesion force is greatest.''

Experience must determine the degree to which a vessel should be occluded, although one may make the general statement that if after the rolling instrument has been removed, there is any pulsation below the site of occlusion, the band should be carefully tightened up by a gentle coiling motion of the thumb and first finger until pulsation is imperceptible. This is, of course, perfectly possible without complete stoppage of the blood flow.

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CHAPTER X

STATISTICAL STUDY OF THE TREATMENT OF ANEURISMS

Most of the recent statistical studies on the treatment of aneurisms have failed of practical satisfaction because, for the greater part, they have been incomplete and practically all have dealt with the affection in a single vessel and by a single method of treatment. These studies have reviewed the field from the early days of pre-antiseptic surgery and have compared the results of the last half century with those of to-day—an interesting but not practically profitable survey.

It has seemed best to me, therefore, to include in this chapter an analytical study of modern methods and present-day results in such form that it can be of immediate practical help. For example, the surgeon who has in charge a case of aneurism of the subclavian artery or the femoral artery or any of the larger vessels can by the use of the tables which follow ascertain at once the statistics as to mortality, percentage of cure, liability of gangrene of the extremity or disturbance of circulation and function, and the best method of treatment. The painstaking study of Dr. Halsted on the "Common Iliac Artery"[1] gives such information, but only for the one vessel.

There is one entirely complete review of the whole subject of aneurisms—that by Monod and Vanvert.[2] These authors have made a most remarkable series of studies of blood-vessels in almost every phase of surgery, giving to surgeons of all countries an inestimably valuable work.

[1] W. S. Halsted: The Effect of Ligation of the Common Iliac Artery on the Circulation and Function of the Lower Extremity, Bull. of the Johns Hopkins Hospital, July, 1912.

[2] Revue de Chir., vols. xli and xlii, 1910.

Their carefully compiled tables of results and methods, condensed and studied in a way somewhat different from the original, are here in grateful acknowledgment incorporated.

I shall not state the method of operation done in each case that resulted fatally nor the other small factors that combined to cause the unfortunate result, unless there be some special reason for so doing. The age of patients and the condition of their vessels will likewise be omitted in general. A consideration of these details, important though they are, would thwart the purpose of this chapter, which, as stated above, is to give to the busy surgeon a concrete idea of the treatment and results of aneurisms in general, to let him know in as short a space of time as possible and as accurately as a study of statistics will permit how he had best handle a given form of aneurism and what, in general, he might expect if he does follow the advice given. To those who wish to go into the subject at greater length, I would recommend a perusal of Monod and Vanvert's original memoirs and a study of some of the less pretentious monographs on the subject, references to which are appended.

ANEURISMS OF THE BASE OF THE NECK.[3]

Included in the monograph of Monod and Vanvert on aneurisms is a series of thirty aneurisms which are arbitrarily classified under the heading "Aneurisms of the Base of the Neck"—probably because they do not fit into any one category, such as subclavian, aortic, or innominate aneurisms, but are, so to speak, hybrid, in that all the vessels at the root of the neck may or may not be involved. And as this is the case it necessarily follows that all these vessels have to be reckoned with in the treatment, a different combination being involved in each instance.

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[3] Monod and Vanvert, Rev. de Chir., vol. xli, 1910.

The study and tabulation have been exceedingly difficult and rather unsatisfactory, because, owing to the desperate nature and situation of many of the aneurisms and the consequent necessity of ligating one or more of the largest vessels given off from the aorta, but little can be expected in the way of a permanent cure. An improvement and prolongation of life in comfort should in this series constitute a successful result of the operation. To regard the figures in any other light would but give an erroneous picture of the results obtained in a condition desperate in practically every aspect.

I have, therefore, studied and tabulated these cases in the following way:

1. Cases that are considered complete recoveries by the respective authors are classified as such.
2. Cases which have lived a considerable length of time but have ultimately succumbed to the original condition are classified as *improved*.
3. Cases which have died on the table or within a few days after the operation—from whatever cause—are classified as *immediate mortality*.
4. Cases which have been observed for a short time only and then lost sight of are classified as *doubtful*.

All cases collected between the years 1885 and 1909:

		Per cent.
Number of cases	30	
Recoveries	10	=37
Improved	7	=25.9
Total		62.9
Immediate mortality	10	=37
Doubtful	1	
Eliminated in computation of percentages.		
Unimproved	2	
Eliminated in computation of percentages.		

Immediate death caused by:

	Cases
Hemorrhage	3
Suffocation (hemorrhage?)	1
Cerebral anæmia	1
Hemiplegia	1
Exhaustion	1
Coma	1
Not stated	2

Cause of death in the improved cases:

	Cases
Rupture of aneurism into pleura	1
Six months post-operative.	
Rupture of aneurism into pleura	1
Two years post-operative.	
Not stated	5

In one case there was apparently complete loss of function in one of the arms, while in another there was partial loss. In no case did gangrene occur.

Operative procedures:

1. Ligature of common carotid and subclavian[4] 19, with following results:

Deaths	7
Recoveries	5
Recoveries with weak arms	2
Improved	4
Doubtful	1

2. Ligature of common carotid alone 1
One improved.

3. Ligature of common carotid and subclavian and first part axillary 1
One recovery.

4. Ligature of common carotid and first part axillary 4
Three recoveries. One death—coma.

5. Ligature of common carotid and innominate 2
Two deaths.

6. Ligature of innominate alone 3
Three deaths.

In considering these results, depressing though they are, one cannot help but be forcibly impressed with the peculiarly dastardly results following ligation of the innominate artery. Attention to this fact has been called by Savariaud,[5] who collected 12 cases of ligation of this vessel between the years 1884 and 1906, no ligations of choice being done after 1895, but two being necessitated during those years by post-

[4] Part of the subclavian stated in about half of the cases only, so I thought best to leave out this feature.

[5] Rev. de Chir., 1906, xxxiv, 1.

operative hemorrhage after ligation of other vessels, one getting well, the other ending fatally. Of the entire 12, one case is not reported completely, four recovered (not stated for how long), and seven died. It follows then as Ellsworth Elliott, Jr.,[6] has said, "That ligation of the innominate should have been discarded as a matter of choice is more than justified by the successful results achieved by distal ligation for aneurisms of the innominate or the first part of the subclavian or both. Of distal ligation for aneurism of the first part of the subclavian Savariaud has collected nine cases without a death. In four of these in which the common carotid was tied as well, three were completely cured."[7]

ANEURISMS OF THE COMMON CAROTID ARTERY[8]

All cases collected between the years 1894 and 1908:

		Per cent.
Number of cases	26	
Recoveries	20	=76.9
Deaths	3	=11.5
Doubtful	2	
Eliminated in computation of percentages.		
Arrested	1	
Eliminated in computation of percentages.		

Cause of death:

From hemorrhage during operation	1
From post-operative pneumonia (35th day)	1
From hemiplegia and œdema of lungs (3rd day post-operative)	1

Complications:

Pupillary disturbances, temporary	2
Mental disturbances, temporary	2
Facial paralysis	1
Hemiplegia (one fatal)	2

[6] Annals of Surgery, July, 1912, p. 86.

[7] In all the others there was considerable improvement, as a result of which Savariaud recommends distal ligation of the third part of the subclavian for aneurisms of the first part of that artery, with ligation of the common carotid as well, should the innominate be dilated.

[8] Monod and Vanvert, Rev. de Chir., vol. xli, 1910.

Operative procedures:

Proximal ligature	8
Seven recoveries and one doubtful case.	
Distal ligature	3
One recovery and one doubtful and one arrested case.	
Incision	2
One recovery and one death.	
Extirpation	12
Ten recoveries and two deaths.	

A glance at these tables will show that there was no mortality in the 11 cases of simple ligation, but that two deaths occurred in a like number of extirpations. This, it seems to me, is about what one would expect. It is usually more difficult to extirpate an aneurism than to do a simple ligation no matter what vessel is being dealt with, because, owing to the friability of the aneurismal wall and adhesions between it and adjacent structures, especially veins, there is always the prospect of hemorrhage which may at times be uncontrollable. Radical extirpation, therefore, should not be resorted to where some other simpler operation like ligation or Matas's operation of endo-aneurismorrhaphy will answer the purpose just as well.

LIGATION OF THE INTERNAL CAROTID—EXTRACRANIALLY

Nine cases collected between the years 1890 and 1906—no mortality.

In one case there was paralysis of the hypoglossal nerve following injury in course of the operation—extirpation of the sac of the aneurism. No other complications.

ANEURISM OF THE SUBCLAVIAN ARTERY [9]

All cases collected between years 1898 and 1908:

		Per cent.
Number of cases	18	
Recoveries	15	=83.3
Deaths	1	= 5.5
Improved	2	=11.1
Secondary hemorrhage	0	
Gangrene	0	

[9] Monod and Vanvert, Rev. de Chir., vol. xli, 1910.

Cause of death:

Uncontrollable hemorrhage during course of operation, which consisted of ligation of innominate and common carotid and incision of sac.

Complications:

Paralysis of arm	1
Disturbance of circulation	1

Operative procedures:

Subclavian ligated (3 alone.)	10
First part	8
Second part	1
Third part	1
Not stated	1
Innominate and first part subclavian and common carotid	1
Cure, recurrence having taken place after ligature of innominate alone.	
Innominate and first part subclavian	1
One cure.	
Innominate and common carotid and incision of sac	1
One death.	
Innominate ligated distally alone	1
One cure.	
First part subclavian and inferior thyroid and vertebral and third part axillary	1
Cure, recurrence having taken place after ligation of first part subclavian.	
First part subclavian and common carotid	1
One cure.	
Third part subclavian and common carotid	1
One cure.	
First part subclavian and first part axillary	1
Paralysis of arm.	
First part subclavian and axillary	1
Circulatory disturbance.	
Ligation of carotid	3
One death and two cures.	
Extirpation	4
Four cures.	

We thus see that in 10 out of the 18 cases it was necessary to ligate two or more vessels in order to effect a cure, and that in this series all the mishaps occurred. This multiple ligation was done in several cases at a second operation, a

recurrence having taken place after ligation of a single vessel. Worthy of note, too, is the fact that, in both of the cases of trouble in the arm, ligation of the axillary artery was part of the operative procedure, thus bearing out the well-known observation that "the further away from the heart at which the main arterial trunk is ligated, the greater the danger of functional disturbance and gangrene."

ANEURISMS OF THE AXILLARY ARTERY [10]

All cases collected between the years 1895 and 1909:

Number of cases [11]	24	
		Per cent.
Recoveries	23	95.8
Deaths	1	4.2
Gangrene	0	
Functional impairment	5	20.8
Post-operative hemorrhage	2	8.4

Operative procedures:

Extirpations [12]	14
Functional impairment	3
Death	1

In this case after extirpation a venous transplant was sutured between the ends of the artery, patient dying of delirium tremens several days later.[13]

Ligation of subclavian	9
Functional impairment	2
Post-operative hemorrhage	2

One case resulted from infection.

The striking feature of this series of cases is the number of functional impairments, which after all should be the criterion of success or failure in aneurisms of the extremities, there being little or no occasion for mortality. It would seem

[10] Monod and Vanvert, Rev. de Chir., vol. xli, 1910.

[11] Monod and Vanvert cite one other case which I threw out because the aneurismal sac was removed when an exarticulation of the shoulder-joint was done.

[12] During the course of these extirpations the vein was resected three times without apparent complications.

[13] Lexer, Arch. f. klin. Chir., 1907, lxxxiii, 458.

as if Matas's operation offers better results in these aneurisms than either extirpation or ligation.

ANEURISMS OF THE BRACHIAL ARTERY [14]

All cases collected between the years 1895 and 1909:

Number of cases	22
Recoveries	22
Gangrene	0
Functional disturbances	2

Operative procedures:

Extirpation	18
Vein was resected once without complications.	
Functional disturbances	1
Proximal ligature	2
Functional disturbance	1
Incision	2

In several of these cases the radial pulse reappeared after a number of days' absence—once after 46 days. Its presence or absence cannot, therefore, be of any great prognostic value. In both of the noted cases of functional disturbance it was present almost immediately after operation, although in one it was barely perceptible. In one of the cured cases it was never present after operation.

LIGATION OF THE COMMON ILIAC ARTERY [15]

All cases collected between years 1880 and 1912:

	Per cent.
Number of cases	30
Recoveries	16 = 53.3
Deaths	14 = 46.6
Gangrene	12 = 40

In most all of these cases there were complications (see page 90) other than the simple ligation of the vessel, which contributed quite materially to the bad result. So marked were these complications that Dr. Halsted came to the conclusion, after careful consideration of each individual case, "that the uncomplicated ligation of the common iliac artery is not likely to be followed by gangrene, the percentage being from 3.3 to 6.6. instead of 33.3

[14] Monod and Vanvert, Rev. de Chir., vol. xli, 1910.

[15] W. S. Halsted, Bull. Johns Hopkins Hospital, July, 1912.

(as given by Matas in vol. v of Keen's Surgery); and that the mortality . . . is at most 10 per cent. and probably not more than 6.6 per cent., or it may even be as low as 3.3 per cent."

Gangrene:

In two of the 12 cases of gangrene, the condition was present *before* operation and in three other cases it was very slight.

Recoveries:

In five out of 16 recoveries there was some functional impairment, usually slight.

Cause of death:

Difficult and prolonged operation and hemorrhage	2
Infection	2
Both cases were done in the pre-antiseptic era, 1871-79, but were not reported till 1880 and 1885 respectively.	
Nephritis	1
Possibly due to increased blood-pressure.	
Pre-operative gangrene and hemorrhage	1
Peritonitis, thrombosis, and gangrene	1
Hemorrhage and gangrene	1
Hemorrhage	1
Ligation of aorta 37 days after ligation of common iliac.	
Pre-operative gangrene of scrotum, hemorrhage and diarrhœa	1
Miliary tuberculosis	1
Arteriosclerosis and gangrene	1
Hemorrhage	1
Not stated	1

I have thus tabulated the various causes of death in each case in order to show how easily one could be misled if he merely consulted the table and its accompanying percentages, and I went into the details of the gangrene cases for a similar purpose. The percentage of gangrene is by no means 40 nor is the mortality anywhere near 46.6. In nearly every case there were contributing causes other than simple ligation of the common iliac artery. For example, in two cases the gangrene was present before operation and in the list of deaths there were two fatalities, which, done in pre-antiseptic times but not reported till well in the antiseptic era, died of infection. Another case died of miliary tuberculosis, several died of hemorrhage, and so on. Dr. Halsted has given a most valuable contribution to the study of aneurisms and I recom-

mend a perusal of the original article to those who are interested in the subject—especially those who have a case of aneurism of the common iliac artery to handle.

ANEURISMS OF THE EXTERNAL ILIAC ARTERY [16]

All cases collected between the years 1895 and 1909:

		Per cent.
Number of cases	24	
Recoveries	15	=62.5
Deaths	9	=37.5
Gangrene	4	=16.6
Functional impairment	2	= 8.3
Post-operative hemorrhage	0	

Operative procedures:

Ligature of aorta (alone) 1
One death.

Ligature of common iliac (alone) 5
Two deaths, one of which had gangrene. Three recoveries, one of which had impairment of function.

Ligature of external iliac (alone) 7
One death, five recoveries and one case lost sight of.

Compression 1
One recovery.

Extirpation 4
Two deaths, one of which died of embolus after end-to-end suture of external iliac. Two recoveries.

Ligature of common iliac and femoral 1
One recovery after gangrene and amputation.

Ligature of external iliac and femoral 4
Two deaths, one of which had gangrene. One functional impairment. One recovery.

Ligature of external iliac and aorta, necessitated by post-operative hemorrhage after ligature of external iliac 1
One death.

It has been generally understood that gangrene of the leg is a common occurrence following ligation of the external iliac artery and the above figures substantiate this belief, at least to a certain degree. The exact reason for this mishap has never been satisfactorily explained. Until the question

[16] Monod and Vanvert, Rev. de Chir., vol. xli, 1910.

has been definitely settled it would seem advisable to use Halsted's method of gradual occlusion of vessels in handling aneurisms of this artery. Matas's procedure, too, might be productive of better results here.

ANEURISMS OF THE FEMORAL ARTERY [17]

All cases collected between the years 1895 and 1909: [18]

		Per cent.
Number of cases	66	
Recoveries	58	= 92
Deaths	5	= 7.9
Gangrene	4	= 6.3
Functional disturbance	1	
Lost sight of	3	

Eliminated in figuring percentages.

Operative procedures:

Ligature external iliac [19] 12

One death. One case lost sight of. Ten recoveries.

Ligature external iliac and femoral [19] 2

Two recoveries.

Ligature femoral artery 5

Four recoveries. One gangrene and amputation.

Ligature femoral and popliteal arteries 1

One death (cardiac).

Extirpation 41

Thirty-two recoveries. Three deaths: 1 post-operative hemorrhage; 1 œdema of lungs; 1 erysipelas; 1 functional impairment; 1 gangrene and amputation; 2 superficial gangrene; 2 cases lost sight of.

Incision 4

Four recoveries.

Compression 1

One recovery.

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[17] Monod and Vanvert, Rev. de Chir., vol. xlii, 1910.

[18] Monod and Vanvert divided these cases into two groups, (*a*) those of the inguinal femoral and (*b*) those of the superficial femoral. We do not make this distinction in this country so far as I am aware, so I have considered the cases altogether, making one group.

[19] These ligations of the external iliac really amounted to a rather high femoral ligature in that most of them were not far above Poupart's ligament.

The results of this series of cases are quite favorable, but I believe even better results will be secured if a more general use of Matas's endo-aneurismorrhaphy is made in aneurisms of this vessel. In the three cases of gangrene which followed extirpation, the vein, being quite adherent to the sac, was either ligated or resected during removal of the sac. This should teach us, I think, that every effort should be made to preserve the vein intact, no matter what operative procedure is adopted. In case of its unavoidable injury it should be repaired. If its resection is required a venous transplant had best be done immediately. It must be admitted, however, that the vein was ligated in several other instances in which there was no disturbance, but this does not alter the facts as above stated. Matas's operation probably offers the best solution. The ideal operation of complete excision of the aneurism followed by arterial anastomosis will also be of service in selected cases.

ANEURISMS OF THE POPLITEAL ARTERY [20]

All cases collected between the years 1895 and 1909:

		Per cent.
Number of cases	151	
Recoveries	147	= 97.3
Deaths [21]	4	= 2.6
Gangrene [22]	22	= 14.5
Superficial gangrene	2	
Functional disturbance	6	= 3.9

[20] Monod and Vanvert, Rev. de Chir., vol. xlii, 1910.

[21] One of the deaths resulted from septicæmia.

[22] In two or three instances the gangrene had started before operation on the aneurism; it continued to progress after operation.

Of the 22 cases of gangrene, amputation of the leg or foot was necessitated in 18 cases, amputation of the toes in four cases. One of these cases was a trophic disturbance and not a true gangrene, but inasmuch as amputation was required it is classified as a case of gangrene.

Operative procedures:

		Per cent.
Extirpations[23]	104	
Recoveries	102	=98
Deaths	2	= 1.9
Gangrene	13	=12.5
Superficial gangrene	2	
Functional disturbance	4	= 3.8
Vein was ligated or resected at time of extirpation	24	Per cent.
Gangrene	3	=12.5
Superficial gangrene	1	
Circulatory disturbance	1	25 per cent.[25]
Œdema of the leg[24]	1	
Ligature of femoral artery	32	Per cent.
Recoveries	31	=96.8
Death	1	= 3.1
Gangrene	8	=25
Functional disturbance	1	
Post-operative hemorrhage[26]	2	= 6.2
Ligature of popliteal artery	2	
Recoveries	1	
Death	1	

Gangrene of great toe in this case.

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[23] In one of these cases after excision of the aneurismal sac, the vein was resected and the resected part transplanted successfully between the two ends of the artery. (J. Goyanes, El Siglo med., 1906, liii, p. 561.)

In another case after excision of the sac, the arterial ends were sutured, the knee being acutely flexed so as to approximate the ends. They were 4 cm. apart. Case successful. (Enderlen, Deutsch. med. Woch., 1908, xxxiv, p. 1581.)

[24] This case was cured one year after operation by transplanting a segment of vein between the two ends of the resected vein. (E. Doyen, 22d Cong. fr. de Chir., 1909, 178.)

[25] This percentage is given to show that in 25 per cent. of those cases in which the vein was ligated or resected at the time of operation some circulatory disturbance occurred, thus, I think, proving conclusively that a serious attempt ought always be made to save the vein. It is more than likely, too, that some circulatory disturbance occurred in cases other than those in which it was noted.

[26] One of these cases was saved by ligating the femoral higher up in its course. In the other this did not stop the hemorrhage, so the external iliac was ligated. The foot then became gangrenous and had to be amputated. These are the only two cases of post-operative hemorrhage reported in the entire series of 151 cases. One of them was clearly the result of arteriosclerosis. Neither case was infected.

	Per cent.
Compression [27]	9
Recoveries	9
One of which was merely improved.	
Incision	2
Recoveries	2
In one of which there was functional disturbance.	
Forced flexion (compression)	2
Recoveries	2

There can be little question, I believe, that a painstaking preliminary study of the collateral circulation of the limb in cases of popliteal aneurism will avert many cases of gangrene that might otherwise occur. It would seem, too, that Matas's endo-aneurismorrhaphy is peculiarly well adapted to the treatment of these aneurisms, and, where conditions warrant, excision of the aneurism followed by a vascular transplant and suture might well be practised.

ARTERIOVENOUS ANEURISMS OF THE SUBCLAVIAN VESSELS [28]

Case I.—Done in 1845:
Double ligature of third part of subclavian artery.
Infection.
Secondary hemorrhage.
Death.

Case II.—Done in 1906:
Attempted excision of sac.
Hemorrhage from jugular vein.
Death two hours after operation.

Case III.—Done in 1906:
Ligation of innominate artery.
Recurrence.
Excision of sac.
Recovery.
Improvement of palsy of arm present before operation.

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[27] Compression was tried in a number of cases and failed, some other operation like ligation or extirpation being then instituted.

[28] Monod and Vanvert, Rev. de Chir., vol. xlii, 1910.

ARTERIOVENOUS ANEURISMS OF THE VESSELS OF THE NECK [29]

All cases collected between the years 1889 and 1910:

		Per cent.
Number of cases	11	
Cured	9	=81.8
Improved	2	=18.1
Deaths	0	

Operative procedures:

Extirpation	4
Proximal ligature of carotid	2
These were the cases in which improvement occurred.	
Distal ligature of carotid	2
Quadruple ligature	3

There were apparently no complications and no post-operative disturbances that were not present before operation, and most of these disappeared, only a few minor ailments remaining.

There were one case of arteriovenous aneurism of the internal carotid (extracranial) and three cases of the external carotid, all of which were cured without difficulty by operation, the first by ligation of the external carotid at its origin, the common carotid and the jugular vein (case of W. W. Keen, *Times and Register*, Philadelphia, 1894, xxvii, 151). The last three were cured by extirpation.

ARTERIOVENOUS ANEURISMS OF THE AXILLARY VESSELS [29]

All cases collected between the years 1885 and 1908:

Number of cases	10
Cures	7
Improved	2
Circulatory disturbance	1
Deaths	0

[29] Monod and Vanvert, Rev. de Chir., vol. xlii, 1910.

Operative procedures:

Extirpation 6
Resection of vein in one case without complication. Circulatory disturbance, one.

Compression 2
Both cases improved.

Ligature 1

Separation of vein and artery followed by suture of holes in each ... 1
Successful.

ARTERIOVENOUS ANEURISMS OF THE BRACHIAL VESSELS [30]

All cases collected between the years 1891 and 1909:

Number of cases 14
Cures 12
Functional impairment 2
Deaths 0

Operative procedures:

Extirpation 11
Resection of the vein once without complications. Functional impairment, two.

Ligature 2
Resection of vein once without complications.

Lateral suture of artery 1

ARTERIOVENOUS ANEURISMS OF THE FEMORAL VESSELS [30]

All cases collected between the years 1890 and 1909:

Number of cases 58
Recoveries 54
Deaths 4
One from septicæmia after ligature of common iliac. One from hemorrhage during operation. Two followed gangrene and amputation after ligature of external iliac.

Gangrene 10
(*a*) In eight cases amputation was necessary, two of these patients dying. External iliac was ligated four times with two deaths. Femoral artery was ligated four times, twice proximal and distal—twice proximal.

[30] Monod and Vanvert, Rev. de Chir., vol. xlii, 1910.

(*b*) In two of these cases the gangrene was only superficial and followed ligature of the external iliac once and extirpation once.

Functional disturbance 2

In both cases the leg was a little weak and followed ligature of the external iliac once and extirpation once.

Operative procedures:

Extirpation 40
Recoveries 35
Deaths 1
Slight superficial gangrene 2

In one of these cases the external iliac was ligated before the extirpation.

Slight weakness of leg 2

In one of these cases the external iliac was ligated before the extirpation.

Ligature of femoral artery proximal and distal or proximal 9
Recoveries 5
Gangrene 4

Proximal and distal ligation twice; proximal alone twice.

Ligature of external iliac artery 7
Recoveries 5
Deaths 2
Gangrene 4
Weakness of leg 1
Ligature of common iliac 1
Death 1

From septicæmia.

Incision 1

Recovery.

A study of these tables reveals the fact that arteriovenous aneurisms of the femoral vessels is a more serious affection than aneurism of the artery alone. It also shows pretty clearly that the external iliac artery had best be given a wide berth. But the most surprising thing of all is the splendid results following simple extirpation and the comparatively poor results following ligation of the femoral artery without extirpation. Perhaps some future study will explain this apparent contradiction. In excising an aneurism of this character, the vein must necessarily be included, and this means ligation of both vessels, a procedure that ought to be more

dangerous to life and limb than simple ligation and more productive of gangrene and functional disturbance. I have gone over the cases carefully and offer the figures for what they are worth, though I must confess they do not "look right."

ARTERIOVENOUS ANEURISMS OF THE POPLITEAL VESSELS [31]

All cases collected between the years 1891 and 1908:

Number of cases 35
Recoveries 34
Deaths 1

Followed extirpation.

Gangrene 6

In two cases amputation was necessary, extirpation being done in one case, ligature of femoral artery and vein in other.

In four cases gangrene was only superficial, extirpation being done in three cases, quadruple ligature in one case.

Functional disturbance 6

In one case leg was œdematous. In one case there was pain and claudication.

In four cases there were muscular contractures, limited motion, pain and paralysis of foot. In all four cases extirpation of the sac was done and in each instance the leg was practically useless.

Operative procedures:

Extirpations [32] 28
Cures 17
Gangrene 4
Functional disturbance 6
Deaths 1
Quadruple ligatures 4

In one case gangrene of toes; In three cases recovery.

Ligature of femoral artery and vein 3

Recovery in two cases. Gangrene and amputation in one case.

Here we have what I expected to find in the study of arteriovenous aneurisms of the femoral vessels—disastrous results following extirpation of the aneurismal sac. The figures speak for themselves and discussion is all but super-

[31] Monod and Vanvert, Rev. de Chir., vol. xlii, 1910.

[32] In two cases of extirpation an end-to-end suture of the artery was done with perfect recovery in each case.

fluous. I cannot refrain, however, from calling attention to the two successful end-to-end sutures that were done after the aneurism had been extirpated. The one was done by Lexer,[33] the other by Stich.[34]

This, of course, is the ideal method of dealing with these and a great many other aneurisms, but the general run of surgeons is not ready yet to do a successful arterial suture. And inasmuch as Matas's operation gives such splendid and uniform results, perhaps it is just as well that such is the case.

[33] Arch. f. kl. Chir., 1907, lxxxiii, p. 438.

[34] Deutsch. Zeit. f. Chir., 1908, xcv, p. 577.

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