THE TECHNIC OF USING VITALLIUM TUBES IN ESTABLISHING PORTACAVAL SHUNTS FOR PORTAL HYPERTENSION*

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EVER SINCE Nikolai V. Eck,[1] a Russian physiologist, successfully performed experimental anastomosis of portal vein to vena cava, in 1877, surgeons have been interested in its clinical application for the relief of portal hypertension. The rare reported instances[2-7] of attempts at the establishment of portacaval shunts by suture, and the by-and-large discouraging results, attest to the technical obstacles to its clinical accomplishment. The technical simplicity and efficiency of the nonsuture method of blood vessel anastomosis using vitallium tubes when employed in the anastomosis of arteries[8] lead to its experimental and clinical trial in the establishment of portacaval shunts.

Basic differences in the hemodynamics of the venous systems *versus* arterial so exaggerate the importance of certain technical aspects in the performance of anastomoses as to make it seem worth while to discuss in some detail the adaptation of the nonsuture method using vitallium tubes to the establishment of portacaval shunts.

At the outset, a general statement may be made, namely, that technical details conceded to be important to the success of arterial anastomosis must be executed with even more meticulous care to insure the success of portacaval shunt anastomoses. The purpose of uniting the portal and caval systems is to reduce portal hypertension and thereby lessen the tendency to gastrointestinal hemorrhage and the formation of ascites. This being true, a shunt capable of handling a large volume of blood should be established.

SPLENORENAL ANASTOMOSIS

This type of portacaval shunt is capable of handling a large volume of blood and, in addition, has the peculiar advantage of eliminating a sizable portion (estimated at 40 per cent) of the total circulating portal blood volume by splenectomy. So far our clinical experience has been limited to end-to-end anastomosis of the splenic vein to the left renal vein using the nonsuture vitallium tube technic. But, the facility with which an end-to-side anastomosis may be carried out using a vitallium tube affords an alternate method to the sacrifice of the kidney.

TECHNIC

The spleen is mobilized. In these cases of congestive splenomegaly it is unnecessary to emphasize that extreme caution must be exercised in the control of hemorrhage during mobilization. The vasa brevia are ligated with transfixion sutures of No. 1 Deknatel and the gastrosplenic omentum cut through. Next, the tail of the pancreas is separated from the splenic pedicle

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and the phrenicolic ligament is cut. This now permits freedom of movement of the spleen for a better examination of the splenic vein in the region of its bifurcation.

It is absolutely essential that the full length of the splenic vein be preserved with minimum trauma during splenectomy. In cases with large spleens in which there is persistent bleeding from disrupted adhesions it becomes

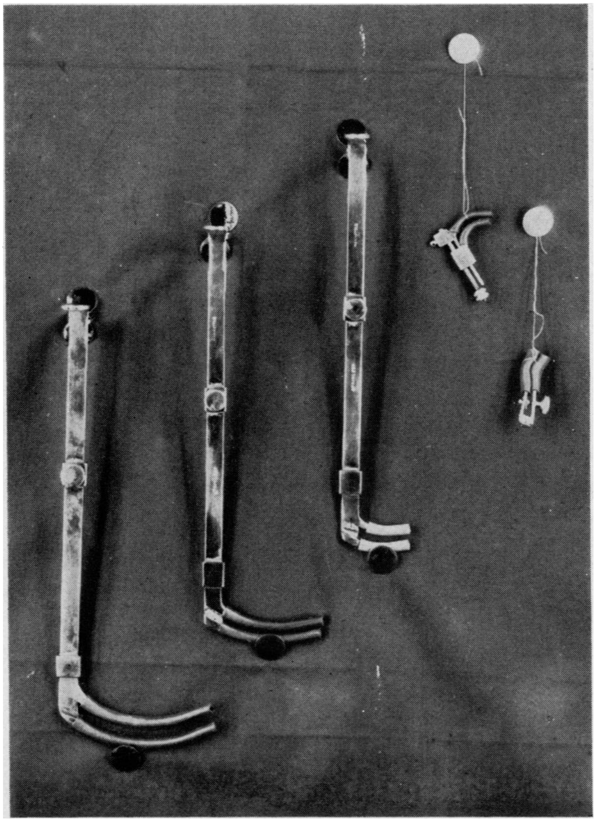

FIG. 1.—Clamps designed by Dr. Armistead Crump for the control of blood flow during the performance of portacaval anastomoses. The two large clamps are suitable for occluding the vena cava. The long handle clamps are easily applied to deep-seated vessels.

necessary to control the splenic artery at once by section between transfixion ligatures of No. 3 Deknatel silk. Otherwise, it may seem wiser, after isolating the artery at the chosen site, to defer ligation until most of the smaller splenic vein branches have been ligated by transfixion ligatures of B and C Deknatel silk. Following ligation of the splenic artery, the spleen may be somewhat emptied of its blood and the splenic vein ligated at once just at its distal primary branching. The blood is then milked far proximalward in the vein and a rubber-shod clamp applied. The smaller rubber-shod clamps illustrated in Figure 1 are handy for this purpose. Immediately following removal of the spleen the stump of the splenic vein should be opened, triangulated with mosquito clamps and thoroughly irrigated with normal saline using a blunt-end syringe.

To effect a comfortable anastomosis of the splenic vein to the left renal vein it is best to mobilize the splenic vein for a distance totaling eight, or more, centimeters. To do this necessitates careful ligation of small pancreatic branches. These branches should be ligated flush with the splenic vein with C Deknatel silk then clamped distally and cut.

A transperitoneal approach is made to the left kidney with retraction of the descending colon medially. The kidney is mobilized and any accessory vessels ligated and cut. The ureter is identified at the lower pole of the kidney, ligated with No. 1 Deknatel silk, clamped proximally and cut. The renal artery is carefully isolated from the vein and ligated at a comfortable site using a transfixion ligature of No. 3 Deknatel. The branching of the renal vein is then studied to make sure that a maximum length of the main renal vein may be preserved for anastomosis. The renal vein is dissected back from the kidney for a distance of five or six centimeters. A rubber-shod clamp is applied as far proximally as possible. The renal artery may then be clamped just distal to the transfixion ligature, cut and again ligated. The vein is sectioned as close to the kidney as possible and the latter removed. Immediately thereafter the stump of the renal vein is triangulated with mosquito clamps and thoroughly irrigated with normal saline.

The splenic vein stump is irrigated with normal saline. A proper-sized vitallium tube (Fig. 2, D) is selected. A tube too large for the vein will present a funnel-like narrowing of the latter after mounting (cuffing). The end of the vein is passed through the tube, triangulated with mosquito clamps and everted (cuffed) over the end of the tube. The vein is held in place by a ligature of No. 1 Deknatel silk placed behind a holding ridge (Fig. 2, A). The tube-mounted splenic vein is freshly irrigated and then wrapped with vaselined gauze.

The renal vein stump is properly trimmed and then triangulated with mosquito clamps. A No. 3 Deknatel silk ligature is laid loosely about the vein. The vitallium tube is grasped with a holding clamp and the intima-covered end is directed toward the renal vein stump. Care is taken to see that neither vein is twisted. They are freshly irrigated with saline, following which the vein-covered end of the vitallium tube is introduced into the renal vein so that the latter comes up well proximal to the tying (holding) ridge on the tube (Fig. 1, A). The previously placed silk ligature is then tied very tightly about the renal vein, approximating it to the splenic vein at a point proximal to the tying ridge upon the tube. A second ligature of No. 3 Deknatel is placed in identical manner. Surgeons knots are essential for the maintenance of the necessary tension in these holding ligatures. Finally, a ligature of No. 1 Deknatel is tied, just snug, about the renal vein approximating it to the splenic vein near the end of the tube. The latter is most important as it keeps blood from penetrating between the two intimas. Figure 1, B shows completed anastomosis. It is arranged to release the rubber-shod clamp on the splenic vein to be immediately followed by release of the rubber-shod clamp on the renal vein. The distended splenic vein should curve gently to its junction with the renal. Any tendency to acute angulation should be corrected. As much peritonization of raw surfaces as is possible should be carried out and careful ligation of any bleeding vessels before closing the abdomen.

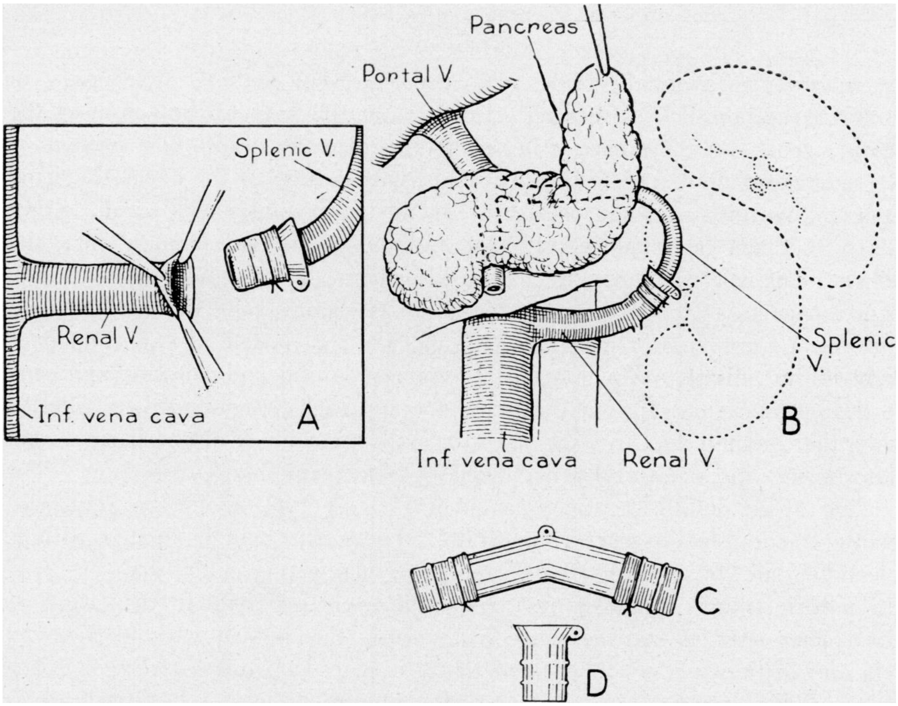

FIG. 2.—A. Illustrating the method of everting the renal vein for the introduction of the vitallium tube bearing the splenic vein. The clamp on the flanged portion of the vitallium tube for its guidance and the rubber-shod clamps upon the splenic and renal veins have been omitted. B. is a semidiagrammatic sketch of the completed anastomosis. Note the placement of the ligatures upon the vitallium tube. C. A vitallium tube with a vein graft mounted. D. An improved design of vitallium tube for end-to-end or end-to-side splenorenal anastomosis. There are two tying ridges placed 2 and 4 mm., respectively, from the end. Note the tab on the flange for the application of a holding clamp.

It is undesirable, for several reasons, to resort to the use of a vein graft in the performance of a splenorenal anastomosis. Though tension and angulation must be avoided, it is our opinion that the use of a graft is rarely necessary providing an adequate length of splenic vein is painstakingly mobilized. In our experience, it was necessary to resort to a vein graft in only one out of five cases. In this case, because of the unusual turgidity of the intervening tissues, due to extreme edema, the splenic vein did not adequately reach the stump of the left renal vein though it apparently had been mobilized over a length of approximately eight centimeters. The gap was bridged using a segment of superficial femoral vein. In the rare case in which the use of a vein graft is indicated, it is our belief that it is best (though this point has not been proven) to employ a vein-lined vitallium tube. Figure 1, C illustrates a vitallium tube, satisfactory in design, for this purpose.

ANASTOMOSIS OF THE PORTAL VEIN TO THE VENA CAVA BY THE NONSUTURE METHOD

The Eck fistula type of portacaval shunt has the advantage of size. An end-to-side anastomosis of the portal vein to the vena cava by the nonsuture vitallium tube technic affords an estimated blood carrying capacity 30 to 40 per cent greater than a splenorenal anastomosis.

TECHNIC

In order to avoid the undesirable use of a vein graft it is necessary to mobilize the portal vein from its bifurcation at the liver to the origin of the splenic vein. At the outset it is best to mobilize the descending portion of the duodenum along its lateral wall. This, with cutting of the hepatoduodenal ligament permits adequate retraction of the duodenum medialward. Since the portal vein lies slightly posterior and medial to the common duct, the above maneuver facilitates medial displacement of the common duct and, hence, permits a lateral approach to the portal vein. Entering the abdomen through a transverse or a right rectus incision with a lateral extension does have the advantage of facilitating a combined lateral and anterior approach to the portal vein. However, whether the approach be combined or anterior only, the common duct is mobilized sufficiently to swing it out of harm's way. The portal vein is carefully mobilized by sharp and blunt dissection. The placing of an umbilical tape or a small Penrose tube about the vein with gentle traction facilitates its dissection. The cystic vein is ligated with C Deknatel silk flush with the portal vein, clamped distally and cut. If the pyloric vein is found at or a few millimeters proximal to the origin of the splenic vein, it may be spared, otherwise it is ligated with C Deknatel silk and sectioned. A rubber-shod clamp is placed on the portal vein at the origin of the splenic vein. A transfixion ligature of No. 3 Deknatel silk is placed around the portal vein at its bifurcation close to the liver, care being taken not to injure the hepatic artery or common duct. The vein is transected four millimeters distal to the ligature. The portal vein is finally irrigated thoroughly with normal saline using a blunt-nose syringe and covered with a moist abdominal pad.

The vena cava is carefully mobilized by combined sharp and blunt dissection from the level of the liver down past the entrance of the left renal vein to the upper level of the right renal vein. The early passage of an umbilical tape about the vena cava with gentle traction serves to facilitate the dissection. Several small vein branches will be encountered posteriorly that will necessitate ligation with C Deknatel silk. A large rubber-shod clamp (Fig. 1) is placed about the vena cava at the upper level of the left renal vein but is not tightened to occlude the vessel.

The portal vein is now passed through a proper-sized vitallium tube. The end of the vein is triangulated with mosquito clamps. The tube is held firmly by a clamp, the end of the portal vein is then everted (cuffed) over the end of the vitallium tube. The vein is held in place by a No. 1 Deknatel ligature tied tightly behind a tying (holding) ridge upon the tube, using a surgeon's knot (Fig. 3). The vein-covered vitallium tube is now swung out from behind the common duct, over the vena cava and a site for the anastomosis is selected. It is most important to select a site that will not result in angulation or compression of the portal vein. The portal vein is again irrigated with normal saline, covered with vaselined gauze to protect the exposed intima and again returned to its former position.

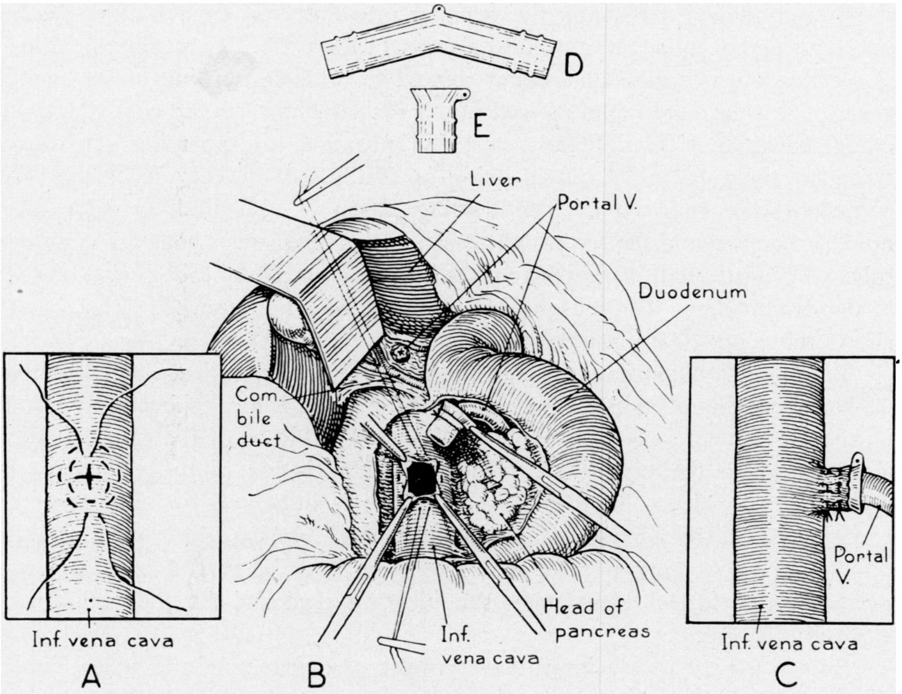

FIG. 3.—A. Illustrating placement of the purse-strings in the vena cava and the centering of the cruciate incision for implantation of the vitallium tube bearing the portal vein. B. shows the tube bearing the portal vein about to be introduced through the opening in the vena cava. C. The completed anastomosis. Note the vena cava wall is drawn well up on the vitallium tube. D. A tube suitable in design for vein graft bridging. E. A late design double-ridge tube with a holding tab.

The area of anterior vena cava wall selected as the site for the anastomosis is cleared of adventitia. New, thoroughly tested No. 3 Deknatel silk, threaded on a small Ferguson needle is introduced as a purse-string in the vena cava wall (full-thickness) at the site chosen for the anastomosis. The silk should be well vaselinized before its introduction. The purse-string is introduced to form a circle the diameter of which is four millimeters larger than the diameter of the vitallium tube selected for the anastomosis. A second circular purse-string, starting at the opposite side (Fig. 3, A) is placed two millimeters outside of the first one.

A second rubber-shod clamp is put in position about the vena cava as close to the liver as possible. The distal rubber-shod clamp is now quickly tightened to completely occlude the vena cava at the upper level of the left renal vein, followed by tightening of the proximal rubber-shod clamp. The time at which the occlusion is made is noted and recorded. A cruciate incision through the vena cava wall, not exceeding in length the diameter of the vitallium tube, is exactly centered within the inner purse-string area. The apex of each quadrant of vena cava wall thus formed is grasped with mosquito clamps and the vena cava irrigated, using several syringefuls of normal saline.

The first turns of a surgeon's knot are placed in each purse-string but not tightened. The vitallium tube bearing the portal vein is grasped with a clamp and advanced through the opening into the vena cava against steady counter traction upon the mosquito clamps (Fig. 3, B). Care must be taken to see that the vitallium tube is not rotated to produce twisting of the portal vein. The vena cava is pulled well up on the vitallium tube so that the inner purse-string, as it is tightened, will fall proximal to the tying (holding) ridge on the tube. The purse-string is finally drawn very tight and the surgeon's knot completed. The holding clamp on the vitallium tube may now be removed and the second purse-string tied just snug about the vitallium tube. The latter will, if correctly placed, tighten about the tube just proximal to the distal ridge. The mosquito clamps may now be removed. Figure 3, C shows the completed anastomosis.

To establish blood flow through the anastomosis first release the proximal rubber-shod clamp on the vena cava. Next release the rubber-shod clamp on the portal vein to be immediately followed by release of the distal rubber-shod clamp on the vena cava. Duration of occlusion of the vena cava is noted and recorded. Finally, the portal vein is inspected for angulation or constriction. Any change of position is noted during the return of the duodenum to its normal position. Omentum may be placed over any unperitonized surfaces. Hemostasis should be checked and the abdomen closed carefully in layers.

Should the use of a vein graft to complete the anastomosis be unavoidable, the external iliac vein more nearly approximates the diameter of the portal vein and only a short segment (6–7 cm.) is required. Figure 3, D illustrates a satisfactory design of a vitallium tube to be lined by a vein graft.

SELECTION OF CASES FOR PORTACAVAL SHUNTS

This paper is based upon experience gained in the establishment of portacaval shunts in ten cases (five splenorenal anastomoses, and five portal vein to vena cava anastomoses). As in the case with points on technic, the experience is too limited to express more than formative opinions regarding the selection of cases for operation and the type of shunt indicated in the individual case.

It goes without saying that the selection of cases is based upon a careful history, physical examination and special studies, including kidney function studies. Convincing clinical evidence of portal hypertension should be procurable in the vast majority of cases preoperatively. Furthermore, one can accurately predict, on the basis of liver function chemistry, whether the portal hypertension is due to intrahepatic (portal cirrhosis) or extrahepatic portal bed block.

A case of splenomegaly giving a history of hematemesis or gastro-intestinal bleeding in association with the presence of anemia, leukopenia, thrombocytopenia and a normal liver function chemistry may be safely diagnosed as congestive splenomegaly due to extrahepatic portal bed block. The splenomegaly may be discovered in infancy or childhood to suggest the presence

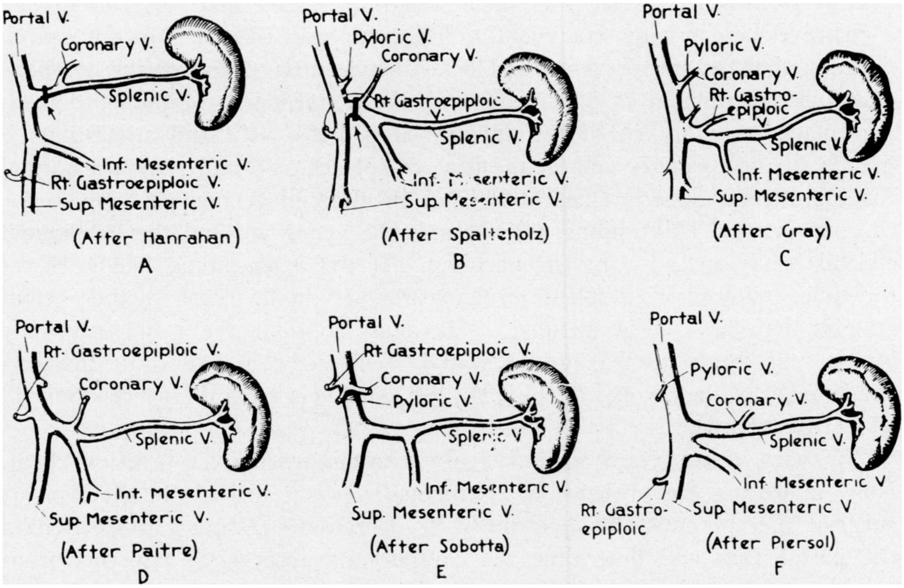

FIG. 4.—Illustrating the anatomic variations in the major branches of the portal vein. Note the effect of a splenic vein block proximal to the origin of the coronary vein.

of portal vein atresia, atresia of the splenic vein at its origin; or, in other cases to follow the history of an injury suggesting splenic vein thrombosis. Rousselot[9] has presented evidence to suggest that congestive splenomegaly when due to a block in the splenic vein may or may not be accompanied by a vicious hypertension localized to the branches of the coronary vein of the stomach (which anastomose with the esophageal veins) in accordance with whether the coronary vein arises from the splenic or the portal veins. If the coronary vein happens to arise from the portal vein, thrombosis of the splenic vein would not, of course, be expected to cause esophageal varices. Or the same would hold in cases in which the coronary vein arose from the splenic vein, provided the thrombosis of the splenic vein were limited to a region of the splenic vein distal to the entrance of the coronary (see Fig. 4). Since four out of the six anatomists list the coronary vein as normally arising from the splenic vein, the chances of a vicious hypertension involving the coronary vein system of the stomach as a threat to hemorrhage from esophageal varices is a real one.

In view of the above facts splenectomy alone as a treatment for congestive splenomegaly should be limited to those cases of splenic vein thrombosis in which the coronary vein arises from the portal vein or, if arising from the splenic vein, the obstruction in the splenic vein must be distal to its origin. Figure 5 illustrates a case in which the above indications were not observed, unfortunately, and there are more about the country. This venogram, made at operation following the injection of a branch of the coronary vein with 35 per cent diodrast, shows the course of the coronary vein (note arrows) directly downward toward the splenic vein. The fact that this patient had a massive hemorrhage six months following the removal of the spleen indicates that the splenic vein was blocked between the origin of the coronary vein and the junction of the splenic with the portal vein. Manometric readings made on a branch of the superior mesenteric vein and another on a branch of the coronary vein at the time of splenectomy had shown a normal reading for the superior mesenteric and an elevated venous pressure in the coronary vein. This finding corroborates the venogram and the subsequent clinical behavior following splenectomy. If the splenectomy had been, at the time, followed by a splenorenal anastomosis, in this case further hematemesis may have been avoided. The only hope of the postsplenectomy bleeders of this particular group would seem to be a vein graft bridging anastomosis of the coronary vein to the left renal vein *via* a thoraco-abdominal, lesser sac approach.

In cases of congestive splenomegaly with a normal liver function chemistry, indicating the presence of extrahepatic portal bed block, the type of surgical therapy must be determined at operation. A quick inspection of the portal vein will determine the presence or absence of cavernomatous transformation. Atresia of the portal vein at the portal fissure may be less easy to recognize. Obstruction sites in the splenic vein, on the other hand, are often extremely difficult to palpate or demonstrate. Venous pressure readings are essential. Figure 6 illustrates a simple device for obtaining readings. Blood pressure in the portal radicals varies normally from 80 to 100 mm. of water. A reading above 110 mm. of water should definitely be considered above normal in our experience. At the outset, a pressure reading should be taken from a branch of the superior mesenteric vein; if this is elevated, it may be taken as evidence of a block in the superior mesenteric vein, portal vein or intrahepatic portal block. A normal reading from a branch of the superior mesenteric vein and an elevated reading from a branch of the coronary vein of the stomach would indicate a block in the splenic vein, and, furthermore, strongly suggest that the coronary vein originates from the splenic vein distal to the site of obstruction. This evidence alone would make us favor performing a splenectomy followed by a splenorenal anastomosis rather than a splenectomy alone. In a case of congestive splenomegaly in which the superior mesenteric pressure is normal, the splenic vein pressure elevated but the coronary vein pressure approximately normal, we would be inclined to perform a splenectomy only. Venography following the injection of 15–20 cc. of 35 per cent diodrast in a branch of the coronary vein is useful in confirming the site of origin of the coronary vein.

In most cases of cavernomatous transformation of the portal vein splenorenal anastomosis is likely to be the only type of portacaval shunt it is practical to use. In some cases of cavernomatous transformation, however, or

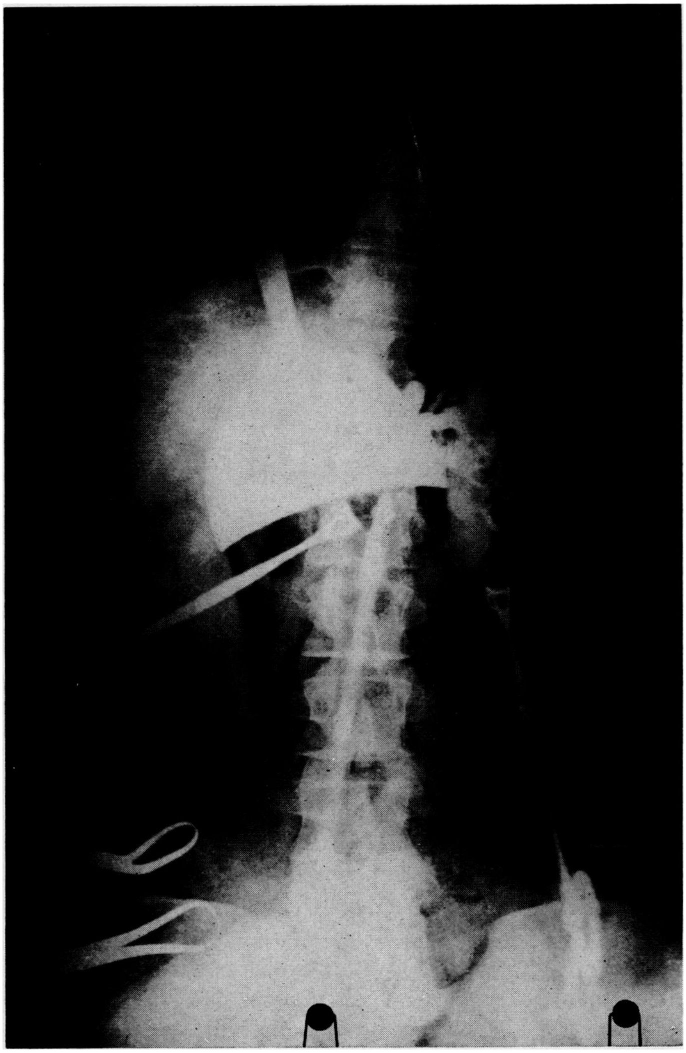

FIG. 5.—Venogram following diodrast injection of a branch of the coronary vein. Arrows point to coronary vein descending toward the splenic vein.

cases of atresia of the portal vein at the portal fissure, in which the spleen has been previously removed, it may be possible to do a portal to vena cava anastomosis using a vein graft. We found it to be feasible in one case.

We are coming to believe that anastomosis of the portal vein to the vena cava may be preferable to splenorenal anastomosis for the treatment of Laennec's cirrhosis of the liver, though it will take time and more experience to settle this point. In cases of cirrhosis of the liver, having very large spleens, it is logical and safe to ligate the splenic artery in addition if, after the portal vein is implanted into the vena cava, the spleen should fail to shrink satisfactorily at the time. We have not found it necessary to do this so far.

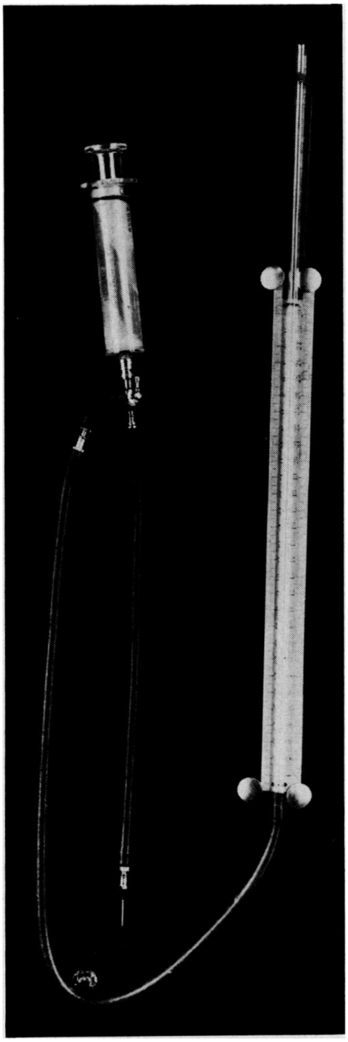

Fig. 6.—Photograph of a manometer and tubing arrangement suitable for taking portal pressures and the injection of diodrast for making venograms of the portal bed.

It is our feeling that the larger volume of blood shunted by the portal vein when implanted in the vena cava in comparison to the amount handled by the smaller splenic vein in a splenorenal anastomosis may more effectively lower the portal tension and reduce the tendency to ascites. In regard to the latter, however, the possible use of the left ureter following nephrectomy to drain off ascitic fluid when properly implanted in the peritoneal cavity must not be lost sight of. Studies are in progress in this direction.

Discussion: There are two important hemodynamic factors that are known to affect the immediate success or continued patency of blood vessel anastomoses, namely, (1) intravascular pressure; and (2) rate of blood flow. Surgeons experienced in the suture anastomosis of blood vessels are about as certain of the success of arterial anastomoses as they are certain of the failure of vein anastomoses. Arteriovenous anastomoses, on the other hand, can be counted upon to remain patent indefinitely and with unfailing regularity. In the former the high intravascular pressure is an important factor favorable to success. In the latter (arteriovenous anastomosis), in addition to the favorable factor of pressure there is an extreme high rate of blood flow, a result of shunting blood from a high pressure (arterial) system to a low pressure (venous) system. These factors insure the perpetuation of anastomoses even though they be formed by the passage of bullets, knives, *etc.*

It seems likely that the important reason for failure of carefully performed suture anastomoses of veins is the low intravascular pressure. The normal systemic vein pressure is under eight millimeters of mercury. This unfavorable factor in combination with cessation of flow due to vasospasm may initiate clotting along the suture line which often rapidly propagates to complete occlusion of the vessel at the site of the anastomosis. The above facts being true regarding the anastomosis of veins in general, the question may very properly be asked, what chance is there of a portacaval shunt remaining permanently open? In the first place, a portacaval anastomosis done for the relief of portal hypertension has the favorable factor of dealing with a greatly increased venous pressure. The portal pressures in our cases ranged from 260 mm. of water (20 mm. Hg.) to over 500 mm. of water (40 mm. Hg.).

A second factor important in perpetuating the patency of portacaval shunts is the extremely high rate of blood flow—the identical factor so important in maintaining the persistence of traumatic arteriovenous fistulae. Though the pressure differential be not of the same magnitude in comparing the two types of shunts, the principle is the same, namely, the shunting of blood from a high pressure (portal) circuit to a low pressure (vena cava), low resistance to flow circuit. It is not unreasonable to venture the statement that the rate of blood flow through a good-sized portacaval shunt may far exceed that of a large artery. In view of the above hemodynamic facts favorable to the perpetuation of portacaval shunts, success or failure in the individual case would seem, then, to depend upon technical factors.

There is full agreement that the ideal technic in blood vessel anastomosis embraces intima-to-intima coaptation without the interposition of a foreign body in contact with the flowing blood. It is conceded that suture anastomoses, when done with meticulous care, may closely approximate the above ideal. But, in our opinion, its application to the establishment of portacaval shunts is impractical. This is because of the presence of complicating factors that are likely to compromise, at some point, the execution of a uniform technic so essential to the success of vein anastomosis, namely, intima-to-intima coaptation without foreign body contact with the flowing blood. For example, it must be remembered that a beautifully performed suture anastomosis, up to a point, may suddenly be ruined by the malplacement of two or three stitches, the execution of which had been compromised by unfavorable circumstances, such, for example, as inadequate exposure, *etc.*

It is our opinion that the nonsuture method of blood vessel anastomosis is peculiarly suited to the establishment of portacaval shunts. The method embraces the ideal feature of intima-to-intima coaptation without intervening foreign body (suture). It is important to remember that the above feature is approximated only in the "perfect" suture anastomosis whereas, it is automatically assured at the completion of the nonsuture anastomosis, irrespective of the difficulties of exposure, *etc.*, that may be encountered during its performance.

In addition to the greater technical ease with which portacaval shunts may be established, using the nonsuture method, it requires less time than the suture technic. Time is particularly an important factor in the performance of a portal vein to vena cava anastomosis (Eck fistulae). This is because it is necessary to completely occlude the vena cava proximal to the entrance of the renal veins during the period the vena cava is actually open, *i.e.,* while doing the anastomosis. Serious kidney damage may result from prolonged blockage of the renal veins. It seems likely that this may have been the causal factor in some of the fatalities reported in the early literature following the performance of Eck fistulae employing the suture technic. One may cut down this period of occlusion of the vena cava to a minimum using the nonsuture technic—the time elapsed from the time of incision of the vena cava to completion of the anastomosis may be, and should be, as little as ten minutes.

In conclusion, we may state that every one of the ten cases of portacaval shunts (five splenorenal and five Eck fistulae) went through a successful postoperative convalescence. The interval following operation has been too short in some to judge the results. However, in six of the ten cases the improvement has already been so outstanding as to justify continuing the procedure. The Eck fistula operation is better tolerated by the patient, probably because of less blood loss during the procedure.

SUMMARY

A nonsuture method of establishing portacaval shunts by anastomosing the splenic vein to the renal vein or the portal vein to the vena cava, employing vitallium tubes is described and illustrated. The indications for the employment of the two types of shunts are discussed and the technic for each described.

The hemodynamics of portacaval shunts are reviewed with special reference to those features of the nonsuture technic that favor maintained patency of the anastomoses.

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