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Interposition Mesocaval Shunt for Treatment of Portal Hypertension

THEODORE DRAPANAS, M.D.*

From the Department of Surgery, Tulane University School of Medicine and the Charity Hospital of Louisiana in New Orleans, New Orleans, Louisiana

ALTHOUGH THE DIVERSION of portal blood into the systemic circulation protects against further hemorrhage from esophageal varices, many problems remain which are related to the use of portacaval or other shunts. These problems include technical difficulties, a higher incidence of rebleeding with procedures which do not give adequate decompression, a high surgical mortality in poor risk patients, postoperative ascites and a high incidence of hepatic encephalopathy after procedures which totally divert portal blood flow from the liver. In recognition of such problems a number of surgeons have seriously questioned the value of portacaval shunts.

Experience in the treatment of portal hypertension has indicated the need for a surgical procedure which could offer lasting protection against further variceal hemorrhage, be readily and quickly performed with a low operative risk and a low incidence of postoperative ascites and encephalopathy.

With the increasing knowledge and ready availability of synthetic grafts for vascular surgical procedures, approximately 3½ years ago we began a prospective evaluation of a large diameter dacron graft interposed between the superior mesenteric vein and the vena cava (Fig. 1) for management of variceal hemorrhage due to cirrhosis of the liver and portal hypertension.

Patient Selection

The criteria of Child [4] were utilized to evaluate all patients initially treated for variceal hemorrhage from portal hypertension. These patients were classified as group A (excellent risk), group B (moderate risk) and group C (poor risk). Because of the excellent results currently obtained by ourselves and others with the use of portacaval shunts, either end-to-side or side-to-side, in the class A category, such patients were excluded from this study. Similarly, all patients with portal hypertension due to extrahepatic portal thrombosis were not included in this study although an interposition shunt is probably the ideal operation for this group.

Figure 2 depicts classification according to risk of the 25 patients who have interposition mesocaval shunts for relief of hemorrhage from esophageal varices. Twenty patients had Laennec's cirrhosis and five patients had postnecrotic cirrhosis. They were almost equally divided between an advanced "B" and a "C" classification. There were 15 men and 10 women with a median age of 41 years. The youngest patient was 24 years of age and the oldest was 55 years of age.

All patients were admitted to the hospital because of acute exsanguinating variceal hemorrhage. No prophylactic shunts were performed. In 19 patients, acute hemorrhage was initially controlled by the Blakemore-Sengstaken tube which adequately prepared the patients for the shunt procedure during the ensuing few weeks. However, in six patients because of continuing or recurrent hemorrhage the shunt was undertaken at an emergency procedure either shortly after admission or early in the patient's hospital course.

Evaluation consisted of a complete liver biochemical profile and an upper gastrointestinal series with a barium swallow x-ray. In 15 patients, gastro-esophagos-

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* Henderson Professor and Chairman, Department of Surgery, Tulane University School of Medicine and Surgeon-in-Chief, Tulane Division, Charity Hospital of Louisiana in New Orleans.

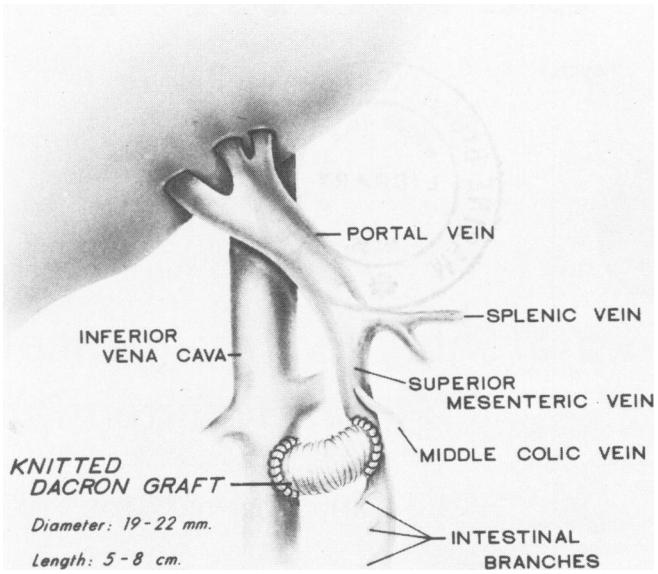

FIG. 1. Interposition mesocaval shunt. In every instance the shunt was a knitted dacron graft varying in diameter from 19 to 22 mm. and in length from 5 to 8 cm. An end-to-side anastomosis is performed at each end of the graft to the inferior vena cava and to the superior mesenteric vein.

copy was also performed to confirm the presence of esophageal varices and eliminate other possible causes of massive upper gastrointestinal hemorrhage. In addition to the above studies, a complete hematologic workup and, when indicated, a liver biopsy were performed to confirm the diagnosis of hepatic cirrhosis. In patients with ascites, the plasma electrolytes were carefully monitored and diuretics were administered during preoperative preparation. Because of their advanced hepatic disease, all patients received concentrated albumin preoperatively, in amounts ranging from 50 Gm. to as much as 500 Gm. depending on the initial level of serum albumin and the patient's response to preoperative preparation.

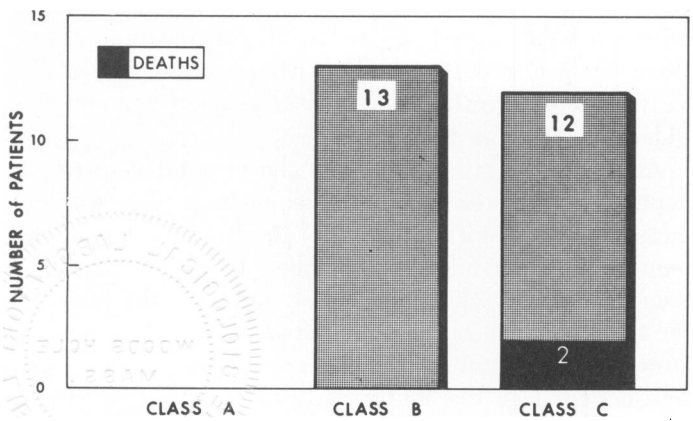

FIG. 2. Surgical risk classification according to the criteria of Child. Thirteen patients were in Class B (moderately severe) and twelve patients were in Class C (severe) category. All good risk (Class A) patients were not initially considered as candidates for this operation and were offered other procedures (portacaval shunt).

Cognizant of the hyperdynamic state which is invariably present in the majority of these patients, the possibility of diminished cardiac reserve and/or cardiac failure was carefully monitored. In two patients digitalization was performed as an adjunct to the preoperative preparation.

All patients who succumbed during the same hospitalization after operation, regardless of the time of death, were classified as operative deaths of which there were two in the entire series. The first occurred on the seventh postoperative day in a comatose, poor risk malnourished patient with marked ascites who had received approximately 12 units of blood preoperatively. Death was due to acute hepatic failure, the patient never awakened after operation and had to be maintained on the respirator until death. The second death occurred in a patient, also operated upon for emergency control of hemorrhage, who had intractable ascites and poor nutrition. Death occurred 30 days after operation due to acute renal failure from over zealous diuresis and an error in postoperative management of the electrolyte problems. The overall operative mortality for the series was 8%.

Pressure Measurements

Intraoperative pressure studies were obtained in every patient before an immediately following the shunt. Following mobilization of a segment of the superior mesenteric vein in the root of the small bowel mesentery at the base of the transverse mesocolon, pressure measurements were obtained by threading a small polyethylene catheter or a long, thin-walled 18-gauge needle into the superior mesenteric vein and passed carefully into the portal vein. Pressure measurements were repeated three times and the mean portal pressure was calculated. The zero level was corrected to the level of the right atrium. Pressure measurements were repeated after completion of the shunt. There was a mean decrease in portal pressure from an initial 365 mm. H_2O before the shunt to 175 mm. H_2O following the shunt, a drop exceeding 50% (Fig. 3).

Follow-up Period

The follow-up of patients from the entire series is depicted in Figure 4. The longest survivor, now 41 months after the shunt, has returned to full activity with no evidence of rebleeding, encephalopathy, or any further hepatic impairment. The mean follow-up period for the entire series is 19 months. To-date there has been one late death in a patient 14 months after the shunt procedure. This patient continued to drink heavily and entered the hospital in terminal hepatic failure with an acute florid type of cirrhosis. At autopsy the liver showed

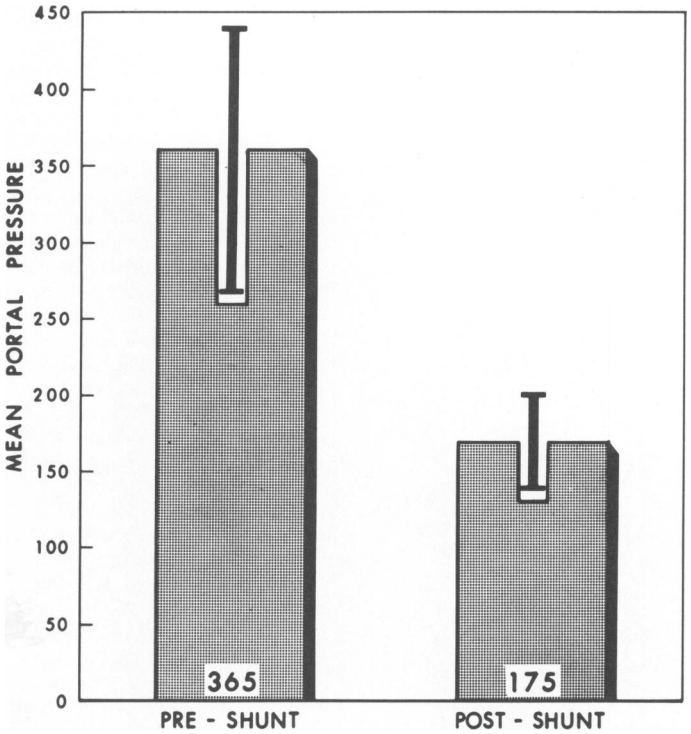

FIG. 3. Portal pressure measurements from entire series of 25 patients. The mean pre-shunt pressure measured at operation was 365 mm. of water. Following the shunt repeat portal pressure measurements showed a significant drop to a mean of 175 mm of water ($p < 0.001$). Standard error of the mean is indicated by the vertical bars.

severe cirrhosis with acute and chronic fatty change, inflammatory cells and deep bile staining. There was no evidence of ascites and the patient had not rebled. His shunt was patent at autopsy.

With this single exception all patients who have survived the operative procedure have continued to do well with no further evidence of derangement of hepatic function or rebleeding. A number of patients, however, have continued to drink alcohol and it would be anticipated that eventually the ravages of alcohol upon the liver may produce a fatal outcome from hepatic failure.

Operative technic (Fig. 5 A, B, C, D)

The abdomen is explored through a long midline incision and the abdominal viscera are carefully evaluated with particular emphasis to eliminate other possible causes for hemorrhage, i.e., duodenal ulcer. The transverse mesocolon is elevated superiorly and the peritoneum overlying the superior mesenteric vessels as they enter the root of the small bowel mesentery is opened transversely. The superior mesenteric vein is carefully freed by sharp dissection avoiding injury to a number of small venous collaterals. In two-thirds of our patients an adequate length (3 cm.) of superior mesenteric vein could be dissected free without interruption of any major intestinal branches. In the remaining third, anomalies of the superior mesenteric vein were present, the most troublesome of which was an early bifurcation of the superior mesenteric vein, each branch containing a significant portion of intestinal venous flow. Rather than ligate one of these branches in order to obtain adequate length for the anastomosis they were carefully preserved and the anastomosis of the graft was made directly at the point of bifurcation after temporary occlusion of each branch with small atraumatic vascular clamps during the performance of the shunt.

Following measurement of the portal pressure via the superior mesenteric vein, the vena cava is exposed directly through the base of the right transverse mesocolon. Early in our series, we mobilized the right colon in order to expose the retroperitoneal vena cava. However, this was frequently accompanied by brisk and troublesome bleeding due to interruption of large venous collaterals. We have now adopted the technic of tunneling directly through the right transverse mesocolon, a maneuver which permits direct visualization of the anterior surface of the inferior vena cava. A mass of lymph nodes is present in the mesentery and these were removed in order to permit as straight a graft as possible through the tunnel.

Another important maneuver at this point was the complete mobilization of the third and fourth portions of the duodenum, including the ligament of Treitz, in order to permit the duodenum to ride up and to prevent

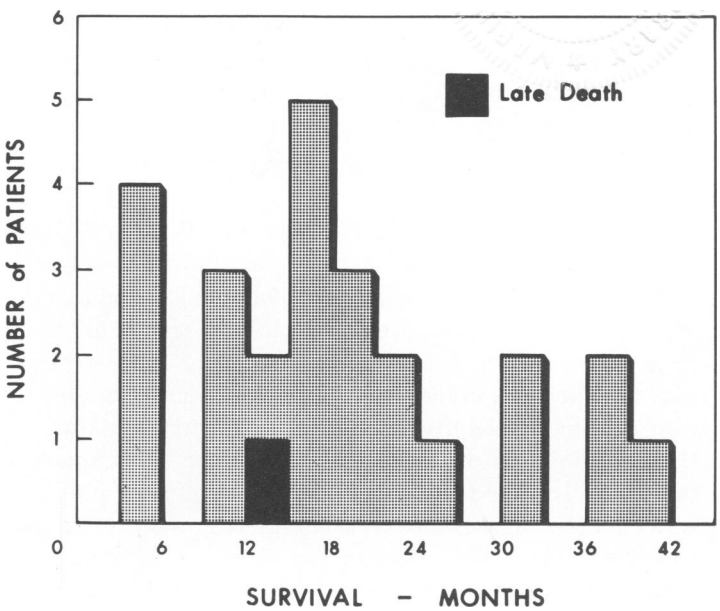

FIG. 4. Follow-up period in entire series. The longest surviving patient is now 41 months after operation. Mean follow-up for entire series is 19 months. The one late death in the entire series occurred in a patient with advanced Laennec's cirrhosis who died of acute liver failure 16 months following the shunt. There has been no rebleeding in any patient to date.

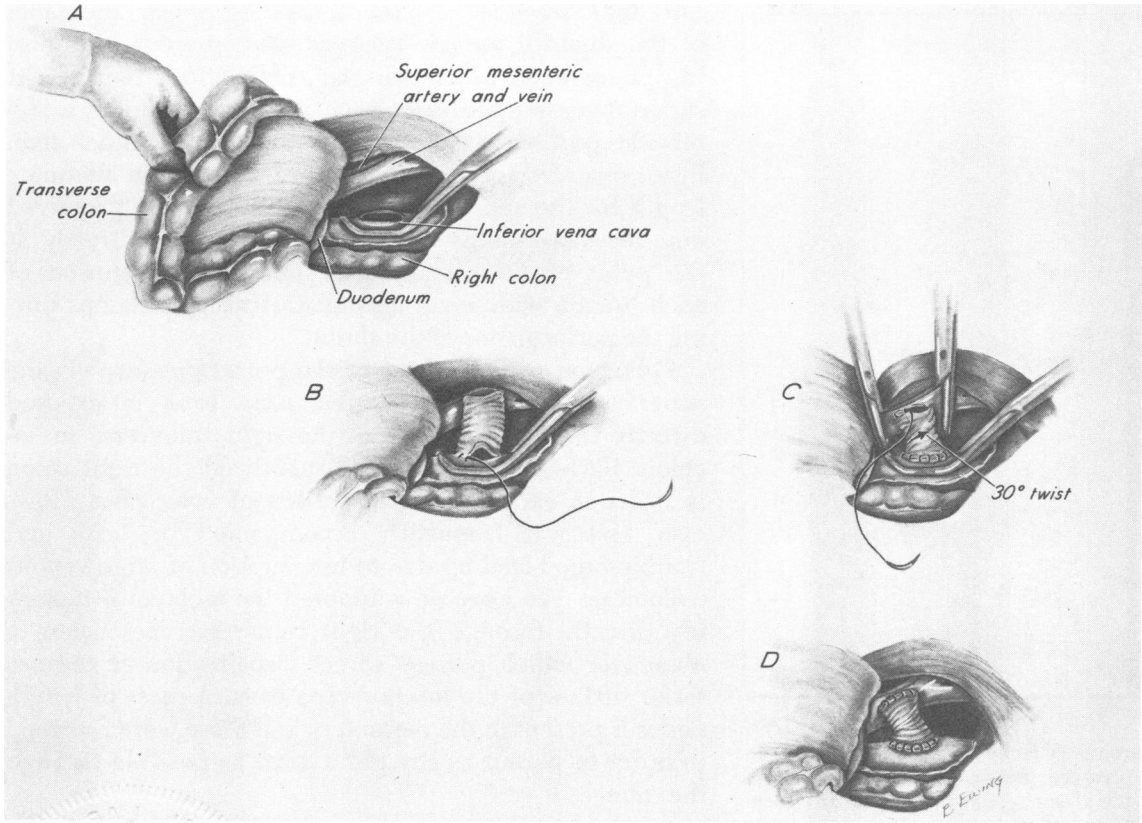

FIG. 5. Operative technic. A, the transverse colon is elevated and the superior mesenteric vein is dissected free at the root of the small bowel mesentery. After appropriate pressure studies are obtained via a small catheter in the superior mesenteric vein, the right transverse mesocolon is then incised and the anterior portion of the infra-renal vena cava is dissected free for a distance sufficient to apply a partially occluding vascular clamp. With increasing experience with this technic we now prefer not to mobilize the right colon to avoid excessive bleeding from the interruption of large retroperitoneal venous collaterals. A small ellipse is removed from the vena cava. B, shows the caval anastomosis being completed with a simple, single row coapting suture using 5.0 vascular synthetic suture. C, the graft is then given approximately a 20–30° clockwise twist to avoid torsion when the viscera are replaced and the end-to-side anastomosis to the superior mesenteric vein is completed. The anastomosis is placed just distal to the middle colic vein which is not shown in this drawing. One or two small intestinal branches must be carefully ligated in order to avoid troublesome hemorrhage during the dissection of the superior mesenteric vein. D, shows the completed anastomosis.

possible obstruction of a low-lying duodenum by the interposed graft. However, should any difficulty arise at this point, it is easily solved by angling the graft caudally and making it a bit longer in order to avoid an anastomosis without tension. The average length of the grafts which we have used in these patients is 6.5 cm. (range 5–8 cm.).

We prefer to do the caval anastomosis first for it lies in the depths of the field and is potentially more hazardous (Fig. 5A). A partially occluding atraumatic vascular clamp is placed on the anterior surface of the vena cava and a small button of caval wall is removed. The anastomosis is completed utilizing a single row of simple coapting 5-0 synthetic vascular suture. Upon completion of the lateral half of the anastomosis, the clamp is pulled to the patient's right and the medial wall of the anastomosis is completed with another running suture. The anastomosis is then checked for leaks and the graft is preclotted by permitting a column of blood to enter it by momentarily releasing the vascular clamp.

Attention is now directed to the anastomosis to the superior mesenteric vein. The graft is trimmed to adequate length, avoiding both tension and too long a graft. Because of the normal course of the superior mesenteric vein over the vena cava at approximately a 20–30° counter-clockwise angle, it appeared advisable to give a 20–30° *clockwise* twist to the graft prior to the start of the

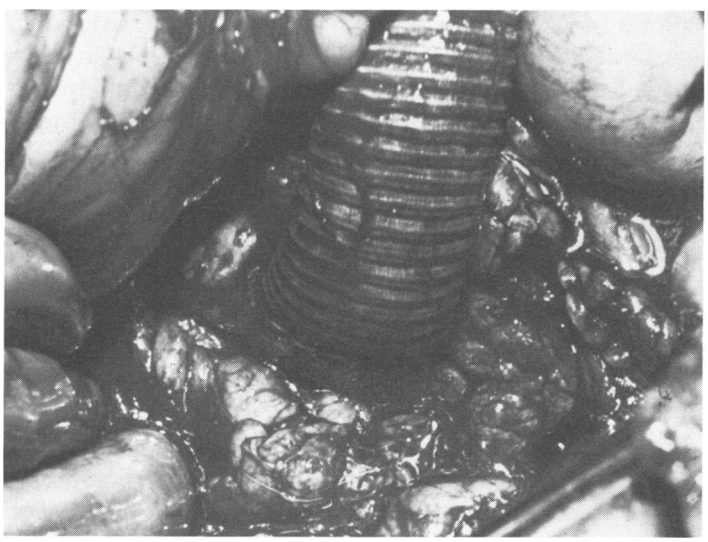

FIG. 6. Operative photograph of completed graft. The anastomosis to the anterior surface of the infra-renal inferior vena cava is shown.

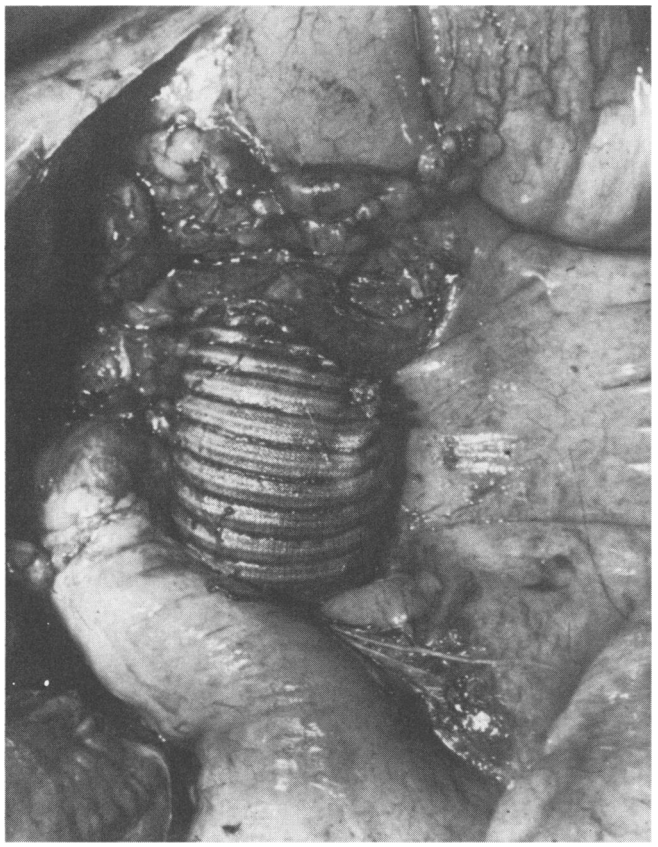

FIG. 7. Operative photograph of completed graft. The anastomosis to the superior mesenteric vein is shown. The route of the graft directly through the right transverse mesocolon limits the extent of dissection and avoids interruption of large retroperitoneal venous collaterals. An effort is made to make the graft as short as possible to avoid kinking. The graft should distend immediately as soon as the clamps are removed. Repeat pressures via the superior mesenteric vein can be obtained at this point.

anastomosis to the superior mesenteric vein. A longitudinal venotomy is made in the superior mesenteric vein after proximal and distal occlusion with angled vascular clamps. A partial occlusion clamp is not needed for the superior mesenteric vein can be safely interrupted during the period of this anastomosis. The anastomosis is made on the posterior surface of the vein, beginning with the medial side of the anastomosis which, of necessity, has to be made within the lumen of the graft. Another suture is then continued completing the lateral wall of the anastomosis. We have not found heparinization necessary. The graft should balloon out quickly as soon as the clamps are removed and the flow of the more saturated superior mesenteric venous blood can be readily seen entering the vena cava through the lower anastomosis (Fig 6). We feel as do Read and others [30,31] that efforts to tunnel these grafts between the duodenum and the pancreas are not only unnecessary but unsafe due to the risk of pancreatitis. The completed anastomosis to the superior mesenteric vein is shown in Figure 7.

Patency of Grafts

Follow-up studies of graft patency have been performed in 15 patients at varying intervals following the shunt. In these patients the grafts have all remained patent (Fig. 8). In three additional patients, which include the two operative deaths at 7 days and 30 days and the late death at 14 months, the grafts were also found to be patent (Figs. 12 and 13). Angiographic studies are planned for the remaining seven survivors.

The technics used for angiographic assessment of graft patency are described in Figures 9–10. The simplest technic involves retrograde catheterization of the shunt via the femoral vein and vena cava. After injection of a 50 cc. bolus of contrast medium sequential films are obtained by a rapid film changer. This technic has the advantage to permitting measurement of superior mesenteric and portal venous pressures directly through the catheter. Trans-shunt pressures can also be obtained by continuous recording during withdrawal of the catheter across the shunt (Fig. 11).

The alternative approach involving selective celiac and superior mesenteric arterial angiography permits an accurate assessment of the flow dynamics in such patients. Patency of the graft can be easily shown by pressure injection of the contrast material into the superior mesenteric artery and obtaining sequential films during the venous phase (Fig. 10A). The dye in the inferior vena cava can be readily identified. More importantly, injection of the celiac axis can also be performed in order to assess the flows in the splenic and portal veins and to determine the presence or absence of prograde flow into the liver from the upper abdominal viscera (Fig. 10B).

The disappearance of esophageal varices is also readily

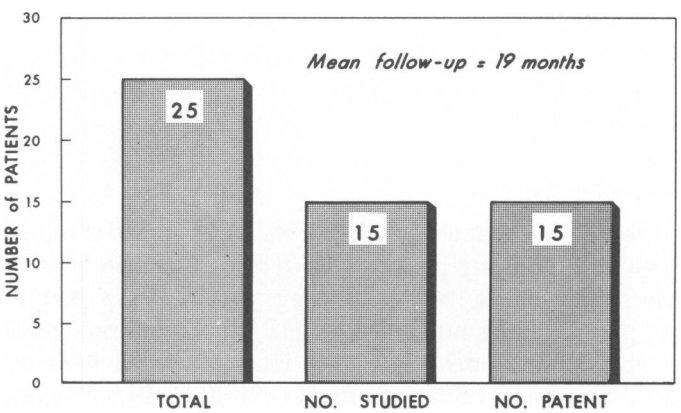

FIG. 8. Follow-up patency of grafts. Angiographic studies were performed in 12 patients. In three additional patients (two operative deaths, one late death) patency was determined at autopsy. In these 15 patients, all the grafts were patent. In surviving patients angiographic studies for patency were performed at least 3 months after operation. The longest documented patent graft is now 38 months.

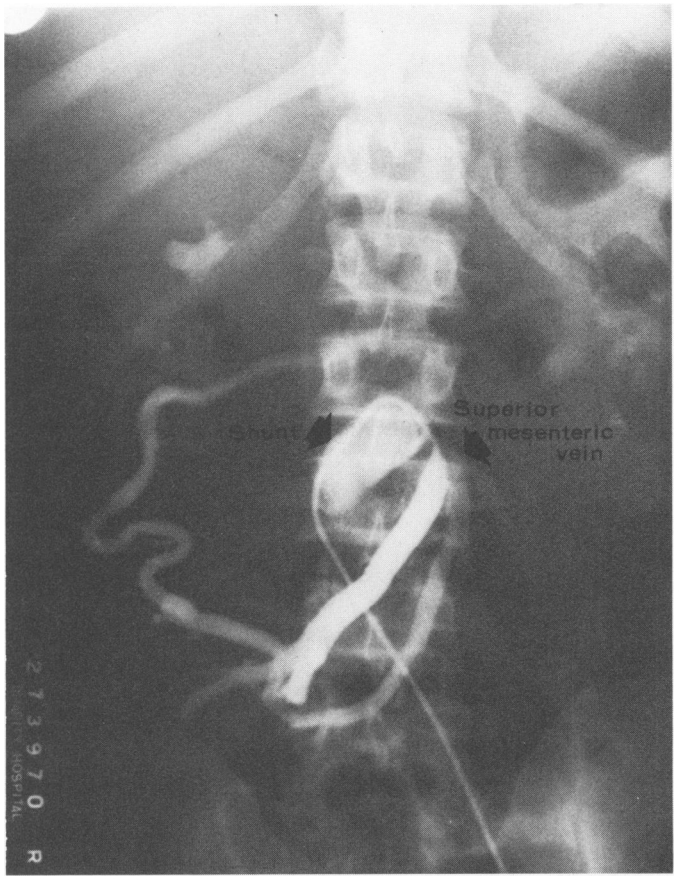

FIG. 9A. Technic of angiographic studies. The graft can be readily demonstrated by dye injection via retrograde catheterization through the inferior vena cava. In this patient, 6 months after operation, a Seldinger catheter was threaded percutaneously via the left femoral vein into the inferior vena cava, through the shunt, and into the superior mesenteric vein. The early injection phase is shown with outlining of the superior mesenteric vein and some of its branches. The ready egress of dye through the large shunt is shown.

demonstrable in the patients studied to date (Fig. 14). However, it has been our observation that varices may be present on x-ray as long as 6 months after the operative procedure.

Metabolic Studies

Repeat liver biochemical profiles were obtained on all patients at varying periods before and immediately after the shunt and at intervals during the follow-up period. As previously mentioned most patients were preoperatively in the moderate or poor risk group. All had hypoalbuminemia, mild to moderate elevations in the serum bilirubin, ascites of varying degrees and altered nutrition. There were consistent elevations in the prothrombin time of a mild to moderate degree. Mean values were meaningless because of the wide variability from patient to patient and are not herein included.

Immediately following operation there was noted a temporary deterioration of hepatic function with a rise in serum bilirubin and transaminases in every patient. Generally, these values returned to normal within a week or two following operation. The blood ammonia levels obtained in these patients are depicted in Figure 15. Four patients had significant elevations in the blood ammonia preoperatively and all four of these patients had encephalopathy of a mild (1+) to a severe (4+) degree. The values shown were representative of the highest blood ammonia levels obtained in any patient during the immediate or long-term postoperative follow-up. However, in view of the well-documented lack of correlation between venous blood ammonia levels and the degree of encephalopathy, a more important observation was the clinical documentation that none of these patients were further impaired by the shunt procedure except the patient who underwent an emergency procedure with preexisting coma. All of the other patients with mild encephalopathy were initially easily controlled by diet, but at the present time, none has required further therapy.

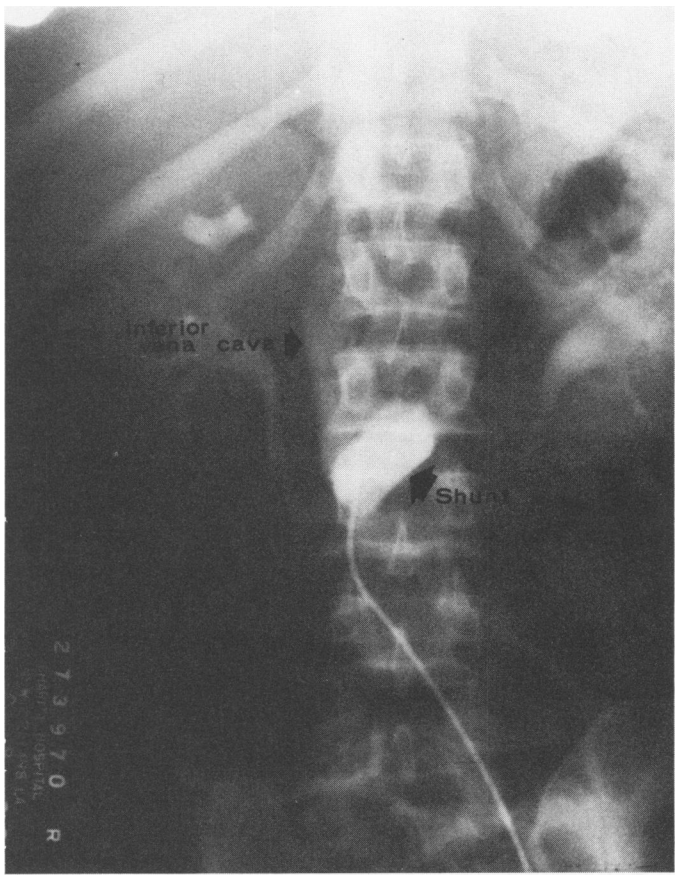

FIG. 9B. Later phase in the same patient shows prompt emptying of the superior mesenteric vein. The bolus of dye is seen entering the inferior vena cava via the shunt, both of which are well opacified.

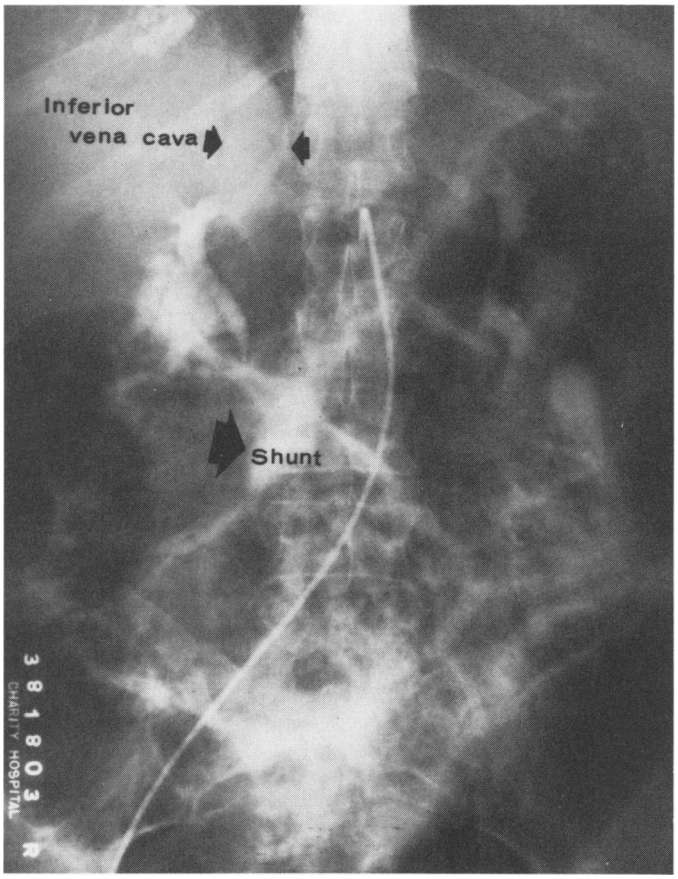

FIG. 10A. Visualization of patent mesocaval shunt by retrograde superior mesenteric artery injection through a percutaneous catheter threaded in the right femoral artery. The venous phase of the study is shown with prompt and early visualization of the shunt and of the inferior vena cava. Such studies reveal in almost every instance virtually complete drainage of the superior mesenteric vein into the vena cava via the shunt.

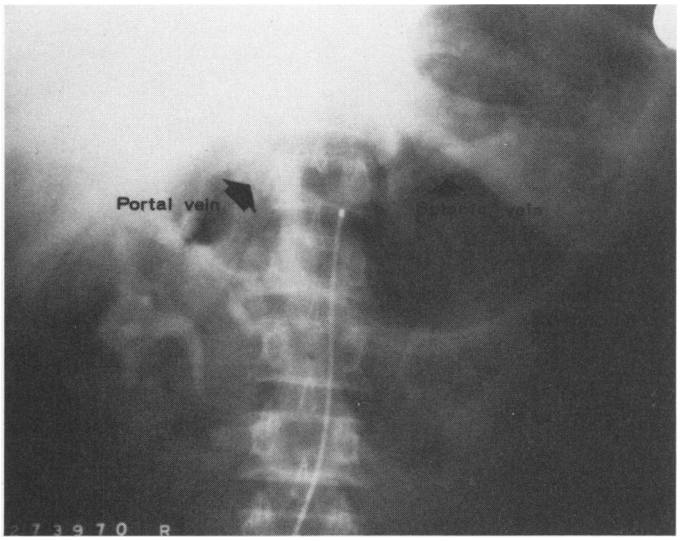

FIG. 10B. Injection of the celiac axis (venous phase) is shown from the same patient. The spleen and splenic vein are well outlined and dye can be also seen flowing into the portal vein toward the liver. This study confirms continued perfusion of the liver from the upper abdominal viscera, namely the splenic veins and coronary veins, despite the fact that the bulk of the superior mesenteric vein flow is into the shunt.

Discussion

Based on these experiences with interposition mesocaval shunt we now feel that the following questions can be answered:

Do grafts interposed between the portal and systemic venous system remain patent? Previous investigators have attempted both experimentally and clinically to bridge the gap between the portal vein and the inferior vena cava. The first interposition of a vein graft between these two structures was carried out in two patients by Reynolds and Southwick [33] in 1951, using the patients' own azygos veins. Theron [35] has described the use of superficial femoral vein and Erlich and associates [10] have sutured the transected end of the left renal vein into the side of the portal vein. Additional studies by Batancourt,[1] Dale and Scott,[8] Nay,[27] and by Nabseth [26] during the past few years have confirmed that venous grafts do remain patent but that adequate caliber is essential to maintain patency.

Among the first to use a prosthetic graft as a shunt between the portal and systemic venous system were Yeoh and Eiseman [39] who in 1962 used Teflon to produce an H shunt between the portal vein and the inferior

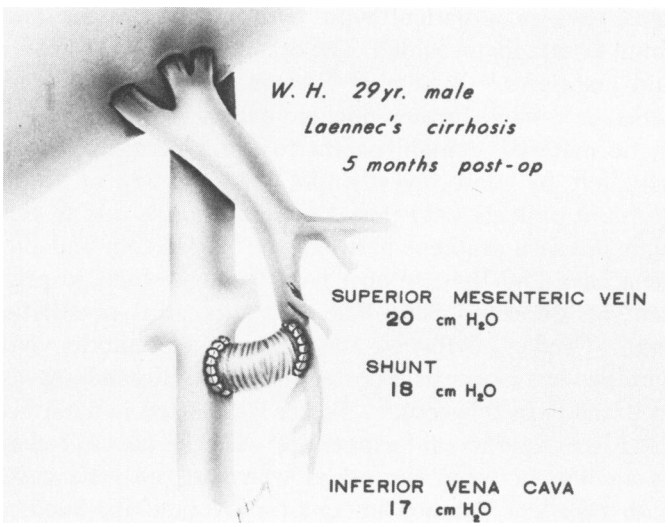

FIG. 11. Pressure gradients obtained in a patient studied 5 months following mesocaval shunt. The inferior vena cava, shunt and superior mesenteric vein were cannulated retrograde via the femoral vein. Superior mesenteric venous pressure was 20 cm. H_2O. Withdrawal pressures revealed 18 cm. H_2O in the shunt and 17 cm. H_2O in the inferior vena cava below the renal veins. Pre-shunt superior mesenteric vein pressure in this patient 5 months previously was 48 cm. H_2O. The esophageal varices had disappeared.

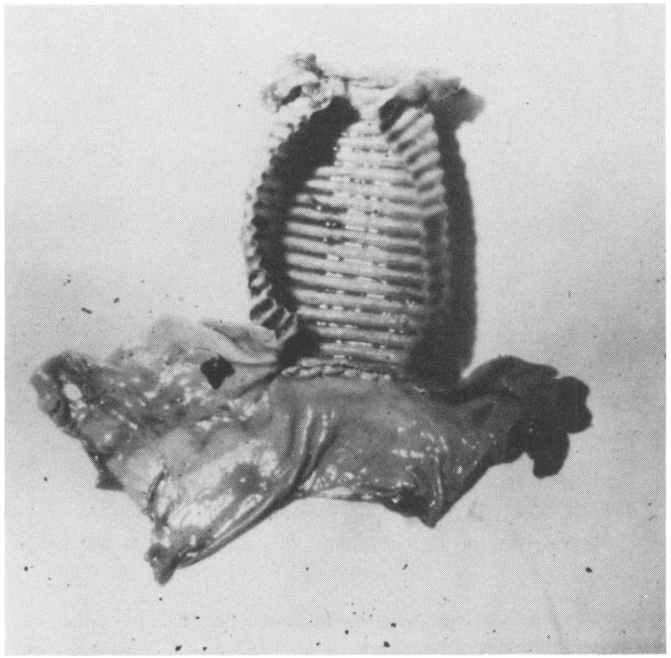

FIG. 12. Graft obtained at autopsy in patient who died from renal failure 30 days after interposition mesocaval shunt. The attached portions of the inferior vena cava (lower) and the superior mesenteric vein (upper) are shown. The graft is patent with a healed suture line and no evidence of thrombosis or contraction is present. This patient had marked ascites preoperatively which could not be controlled by medical therapy, in addition to bleeding varices. Death in this patient was attributed to postoperative error in fluid administration and excessive use of diuretics resulting in renal failure.

vena cava in a patient with portal hypertension. The shunt eventually occluded. The excellent studies of Foster and associates,[11] Symbas,[34] Preston and Trippel,[29] and Nabseth[26] gave further documentation that such prosthetic materials remain patent for long periods. It was now felt by most investigators that patency of these grafts in patients with portal hypertension is due to the high pressure gradient between the portal vein and the vena cava and the use of a large enough shunt to prevent resistance to flow. The first successful prosthetic shunt (Teflon) between the superior mesenteric vein and the vena cava was reported in 1963 by Resende-Alves in Brazil.[32] In this country Foster[11] reported in 1965 his extensive experimental experience with the use of Teflon as a shunt between the portal vein and the vena cava with excellent patency in long-term follow-up. Such a shunt was placed in a patient with portal hypertension and this shunt has remained patent for the past 9 years. Similar confirmation was obtained by Preston and Trippel in their two patients in whom a woven Teflon prosthesis was also used between the portal vein and the vena cava.[29]

Popularization of the technic of an interposition mesocaval shunt came in 1970 when Lord and associates[17] reported on the insertion of mesocaval shunts of woven Teflon with continued patency in three patients with portal hypertension. In the same year Read and associates[30] utilized venous homografts for mesocaval shunt. An additional six patients were reported in 1971 by Lord and associates[18] in which they documented the fact that eight of these nine shunts were patent in a 1 to 5-year follow-up. Read has now placed 18 venous homografts between the superior mesenteric vein and vena cava with 12 long-term survivors.[31] Graft patency has been proven in eight of the nine patients studied and in two additional patients who died of hepatoma after the shunt procedure.

All of these reports confirm a better than 90% patency of either venous grafts or synthetic grafts in the mesocaval position. We have preferred to utilize the large diameter prosthetic shunt because of its ready availability and because of the difficulty in obtaining autogenous vein grafts of adequate size and the logistical problem in obtaining venous homografts from cadavers. We are continuing to use the Dacron prosthesis and see no particular preference to the use of Teflon, based on experiences with arterial prostheses during the past 15 years which indicate a clear superiority of Dacron over Teflon due to the better incorporation of the former into the host tissues.

Is portal hypertension relieved by these shunts? Our own experience and the accumulated experience reported in the literature during the past few years confirms that mesocaval shunts are as effective in protecting against

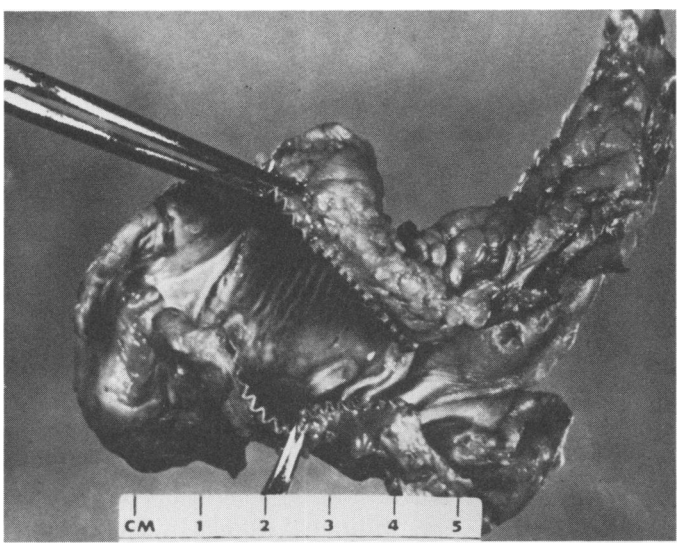

FIG. 13. Autopsy specimen in a patient who died of acute hepatic failure 14 months after interposition mesocaval shunt. The graft is patent with healed anastomoses. Excellent incorporation of fibrous tissue surrounding the graft is clearly evident in this specimen.

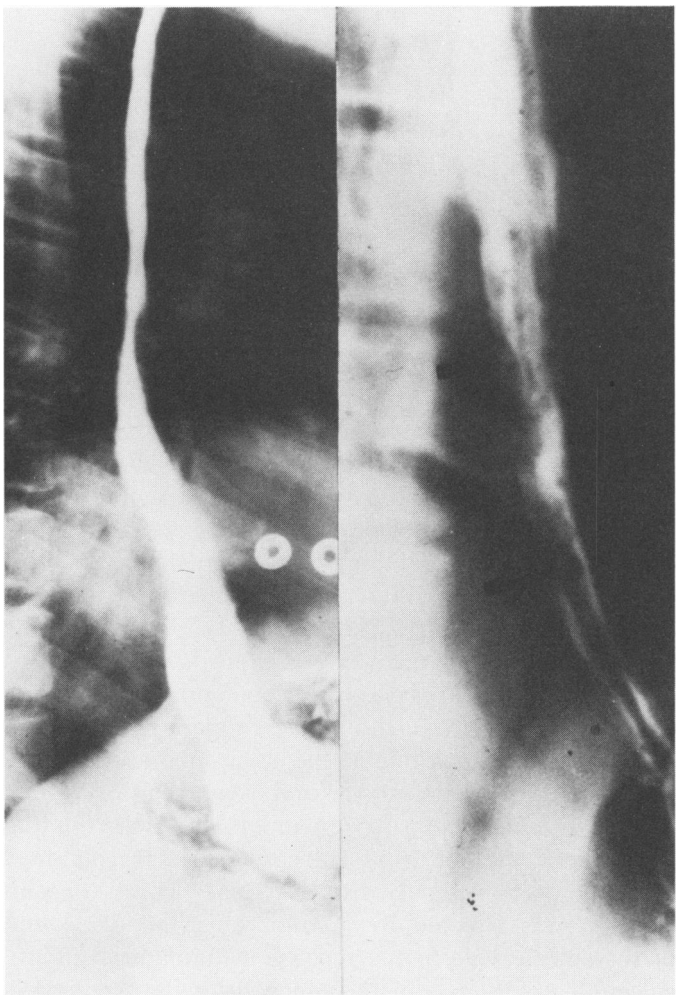

FIG. 14. Esophageal varices demonstrated in a patient before shunt (right). Repeat barium swallow x-ray (left) shows complete disappearance of varices 3 months postoperatively, also confirmed by esophagoscopy.

subsequent variceal hemorrhage as are direct portacaval shunts. Although portal pressures did not return entirely to normal in our own patients, they were reduced by 50% or better in every patient and there has been no further variceal hemorrhage. Possibly, the maintenance of a higher than normal pressure in the superior mesenteric vein may favorably influence the continued patency of these shunts in that it produces a higher gradient between the superior mesenteric vein and the inferior vena cava with minimal resistance across the shunt. In fact, our results at the present time indicate the superiority of this type of shunt in terms of patency over that of other makeshift shunts or even the splenorenal shunt which has been widely popularized by Linton.[16]

Is the interposition shunt technically easy and applicable to most patients? This type of shunt is a variant of the technic originally described by Marion[21] and by Clatworthy[5] who mobilize the vena cava and swing it into the side of the superior mesenteric vein. The Marion-Clatworthy shunt is often accompanied, particularly in adults, with postoperative leg edema due to interruption of the vena cava with its lumbar collaterals. Frequently there is an inadequate length of vena cava to insure a direct anastomosis to the superior mesenteric vein without tension. Because of this inadequacy various alternative approaches have been proposed including the creation of a tunnel between the duodenum and pancreas. The latter procedure has been accompanied by high incidence of complications from possible pancreatic injury. Often considerable kinking may be present which is difficult to avoid. Finally the extensive retroperitoneal dissection required to mobilize the infrarenal cava may be accompanied by troublesome hemorrhage.

When compared to the standard end-to-side or side-to-side portacaval shunt, the interposition shunt requires much less retraction, less dissection in an area rich of venous collaterals and lymphatics and is more rapidly performed. Nor is there the problem of an inadequate length of portal vein to perform the anastomosis, particularly of the side-to-side type, because the interposition graft can be easily tailored to fit. Operative time has averaged in our hands 2 hours or less for the operation and rarely is a blood transfusion required unless, of course, troublesome hemorrhage is encountered due to injury to the superior mesenteric vein or avulsion of one of the small collateral posterior branches. With careful dissection the latter problems can be usually avoided.

Is there preservation of hepatic blood flow? In essence

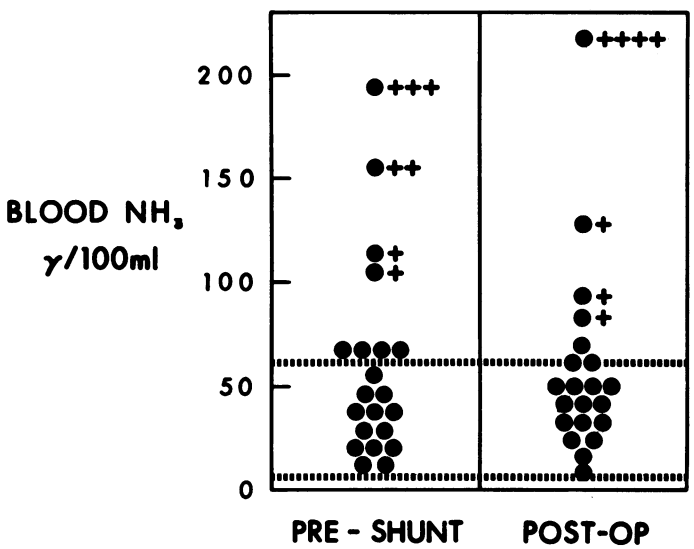

FIG. 15. Maximum venous blood ammonia levels obtained in the entire patient series before and after shunt. The degree of encephalopathy encountered in four patients is graded + to ++++. Encephalopathy was not encountered in any patient in whom it was not present preoperatively. One of these patients was in preoperative coma and died several days following an emergency shunt. Encephalopathy has been easily controlled in the other three patients by dietary measures.

the interposition shunt offers the advantages of a side-to-side shunt [7,22,23,36] between the portal and systemic venous system but at some distance from the porta hepatis. To this extent it functions more like a side-to-side splenorenal shunt but offers distinct advantages over these two procedures in that it is easier to perform and that the superior mesenteric vein is usually large. Furthermore the operative field is considerably drier in this location than is the upper abdomen which is all too frequently the site of enlarged and tortuous venous collaterals which plague the surgeon during the dissection. The inherent advantages of these partially diverting shunts are also twofold: first, in instances where there is continued prograde flow into the liver the possibility remains that despite the decompression of the portal system, some flow can be expected to continue into the liver. We have documented this phenomenon in a number of patients by celiac artery angiography. Similar findings have been reported by Read [30] by splenoportography and by Lord.[17] Conversely, in those patients in which there is a true reversal of portal blood flow in an hepatofugal direction as evidenced by a rising pressure on the hepatic end of the temporarily occluded portal vein, this shunt offers the possibility of decompression not only the splanchnic viscera but also the hepatic sinusoid and thus may be beneficial in the treatment of patients who also have intractable ascites accompanying the variceal hemorrhage.

The interposition shunt compares favorably to end-to-side portacaval shunt from the standpoint of markedly diminished postoperative ascites. In fact, we have encountered postoperative ascites in only one patient following the interposition shunt and this was readily controlled with an intensive medical program. The ascites has not recurred in this patient.

What is the incidence of postoperative hepatic encephalopathy? Numerous investigators have documented the high incidence of postoperative hepatic encephalopathy with both the end-to-side and the side-to-side portacaval shunts.[6,14,23] Britton and Price [2] reported an incidence of 15 to 25% in their patients within 1 year after operation. Similarly Mikkelsen [24,75] has shown a 25% incidence of encephalopathy following an end-to-side shunt and a 50% incidence following a side-to-side shunt in patients followed for 5 years after the surgical procedure. Callow [3] reports a 20% incidence in his series and Warren [37,38] has documented a 50% encephalopathy in his earlier experience with portacaval shunts. The excellent studies of Hassab [13] who has treated a large group of patients with parasitic hepatic cirrhosis led him to abandon the direct portacaval shunt after finding progressive hepatic failure in these patients in a long follow-up despite the fact that these patients had relatively normal livers. Based on his dissatisfaction with portacaval shunts, Hassab now recommends a "decongestion" operation which consists of a gastric devascularization and splenectomy. This procedure has resulted in a lower operative mortality rate, absence of postoperative encephalopathy and better preservation of hepatic function, although there is a higher incidence of rebleeding. Johnson and associates [15] in an extension of the early work of Peters and Womack have also continued to advocate non-shunting devascularization procedures. However these procedures have been accompanied by a high incidence of recurrent bleeding, both in the immediate and late postoperative periods and long-term survival remains in continued risk due to the spectre of gastrointestinal hemorrhage. Despite the absence of encephalopathy in the recent series reported by Johnson, the overall results with the devascularization operation were poor for there was a 43% operative mortality. Of the surviving patients, 45% had recurrent bleeding, 31% required re-operation and 14% had late deaths as a result of this complication. For this reason the devascularization procedure has not received great acceptance in the surgical community.

In an effort to avoid the high postoperative incidence of encephalopathy, while at the same time seeking protection against recurrent variceal hemorrhage, Warren, Zeppa and Fomon in 1967 [38] reported on their initial experiences with a distal splenorenal shunt combined with a "porto-azygous disconnection." Portal decompression was effected by anastomosing the distal end of the splenic vein to the renal vein through an *in situ* spleen. The rationale of the procedure is to decompress the area critical for control of hemorrhage while maintaining a high pressure in the intestinal venous system thereby preserving portal flow to the liver. Similar conclusions were reached by Britton and associates [2] who now recommend selective decompression of the portal system by a central side-to-side splenorenal shunt with ligation of the central portion of the splenic vein.

Results of this type of selective decompression in a retrograde fashion through the intact spleen appear promising in that no encephalopathy has been encountered in any patient postoperatively both by Warren and by Britton. However, the operation is technically difficult and according to Warren can only be applied to approximately 50% of the patients. It is contraindicated in patients with ascites because it does not permit the simultaneous decompression of the high pressure within the portal vein which may have a balanced or reversed flow. Additionally, Warren has reported an initial mortality rate of 30%, although with improved experience, operative mortality rate appears to be approaching acceptable levels. Our experience with the Warren procedure, though limited, confirms the difficulties cited above. More importantly, this procedure

is not available to all patients who have exsanguinating variceal hemorrhage. In view of our satisfactory experience with the interposition shunt which reveals no increase in encephalopathy, at least in the group of patients followed up to 41 months after operation, leads us at present to prefer this operation, particularly for the poor risk patient.

Summary and Conclusion

A 3½ year experience with interposition mesocaval shunt utilizing a wide knitted Dacron graft in 25 consecutive patients is presented. There were two operative deaths (8%) despite the fact that this procedure was performed only upon patients who were poor surgical risks.

There was one late death (14 months) in the entire series due to acute hepatic failure. All of the surviving patients have continued to do well with no deterioration of the hepatic function. Hepatic encephalopathy was encountered preoperatively in four of these patients, one of whom died in the immediate postoperative period. The remaining three patients are now all symptom free without any dietary restrictions.

There has been no recurrence of variceal hemorrhage either in the immediate postoperative period or in long-term follow-up.

Angiographic evaluation of the shunt in 15 patients revealed complete shunt patency in every patient studied. In the two postoperative and the single late death, autopsy revealed patency of each of the shunts with no evidence of kinking, obstruction or thrombosis. The knitted Dacron appeared to be readily incorporated by surrounding fibrous tissue.

It is concluded that synthetic grafts when placed between the superior mesenteric vein and inferior vena cava for the relief of portal hypertension are extremely effective against protection from recurrent hemorrhage, are easily performed, remain patent for a long period, offer the potential for continued perfusion of the liver by an intact portal flow from the upper abdominal viscera, and are accompanied with an extremely low incidence of hepatic encephalopathy. With further experience, particularly in the long-term follow-up of such patients, the eventual role of this procedure in the management of patients with portal hypertension and variceal hemorrhage will become more accurately delineated. Our encouraging results to date have led us now to recommend this operation also to the better risk (Class A) patient.

References

1. Batancourt, J. R., Hirsh, E. F. and Estes, J. T.: Portacaval Shunts: Experimental Use of Various Grafting Materials Constructing a "Y" Shape Shunt. Am. Surg., **35**:516, 1969.
2. Britton, R. C., Voorhees, A. B., Jr. and Price, J. B.: Selective Portal Decompression. Surgery, **67**:104, 1970.
3. Callow, A. D., Resnick, R. H., Chalmers, R. C., Ishihara, A. M., Garceau, A. J. and O'Hara, E. T.: Conclusions From a Controlled Trial of Prophylactic Portacaval Shunt. Surgery, **67**:97, 1970.
4. Child, C. G.: The Liver and Portal Hypertension. Philadelphia, 1964, W. B. Saunders Co., p. 50.
5. Clatworthy, H. W., Wall, T. and Watman, R. W.: A New Type of Portal-to-Systemic Venous Shunt for Portal Hypertension. Arch. Surg., **71**:588, 1955.
6. Conn, H. O. and Lindemuth, W. W.: Prophylactic Portacaval Anastomosis in Cirrhotic Patients with Esophageal Varices. N. Engl. J. Med., **272**:1255, 1965.
7. Cooley, D. A.: Side-to-Side Splenorenal Anastomosis with Splenic Preservation for Portal Hypertension. Surg. Gynecol. Obstet., **116**:626, 1963.
8. Dale, W. A. and Scott H. W., Jr.: Grafts of the Venous System. Surgery, **53**:52, 1963.
9. Drapanas, T.: Current Concepts in the Surgical Management of Portal Hypertension. Am. Surg., **36**:136, 1970.
10. Erlik, D., Barzilal, A. and Schramek, A.: Porto-renal Shunt: A New Technique for Porto-systemic Anastomosis in Portal Hypertension. Ann. Surg., **159**:72, 1964.
11. Foster, J. H., Jolly, P. C., Symbas, P. N. and Dively, W. L.: Vein Grafting in Portal Venous System. Arch. Surg., **91**: 716, 1965.
12. Gliedman, M. L.: The Technique of the Side-to-End Superior Mesenteric Vein to Inferior Vena Cava Shunt for Portal Hypertension. Surg. Gynecol. Obstet., **121**:1101, 1965.
13. Hassab, H. A.: Gastroesophageal Decongestion and Splenectomy in the Treatment of Esophageal Varices in Bilharzial Cirrhosis: Further Studies with a Report on 355 Operations. Surgery, **61**:169, 1967.
14. Jackson, F. C., Perrin, E. B., Felix, W. R. and Smith, A. G.: A Clinical Investigation of the Portacaval Shunt. V. Survival Analysis of the Therapeutic Operation. Ann. Surg., **174**:672, 1971.
15. Johnson, G., Jr., Dart, C. H., Peters, R. M., and MacFie, J. A.: Hemodynamic Changes with Cirrhosis of the Liver: Control of Arteriovenous Shunts During Operation for Esophageal Varices. Ann. Surg., **163**:692, 1966.
16. Linton, R. R.: A Splenorenal or a Portacaval Shunt? Surg. Gynecol. Obstet., **121**:117, 1965.
17. Lord, J. W., Jr., Rossi G., Daliana, M. and Rosati, L. M.: Mesocaval Shunt Modified by the Use of a Teflon Prosthesis. Surg. Gynecol. Obstet., **130**, 1970.
18. Lord, J. W., Jr., Rossi, G., Daliana, M. and Rosati, L. M.: Portasystemic Shunts in the Management of Massive Hemorrhage From Esophageal Varices Due to Cirrhosis of the Liver. Am. J. Surg., **121**:241, 1971.
19. Lord, J. W., Jr.: Personal Communication.
20. Marion, P.: Les Obstructions Portales. Sem. Hop. Paris, **29**: 2781, 1953.
21. Marion, P.: Mesenterico-caval Anastomosis. J. Cardiovasc. Surg., suppl. **70**:70, 1966.
22. Mason, E. E.: Splenectomy and Side-to-Side Splenorenal Shunt for Portal Hypertension. Surgery, **60**:536, 1966.
23. McDermott, W. V., Jr.: Evaluation of the Hemodynamics of Portal Hypertension in the Selection of Patients for Shunt Surgery. Ann. Surg., 1972 (in press). Presented at American Surgical Assn., April 27, 1972.
24. Mikkelsen, W. P., Edmondson, H. A., Peters, R. L., Redeker, A. G. and Reynolds, T. B.: Extra and Intrahepatic Portal Hypertension without Cirrhosis (Hepatoportal Sclerosis). Ann. Surg., **162**:602, 1965.

25. Mikkelsen, W. P.: Personal Communication.
26. Nabseth, D. C., O'Hara, E. T., Marks, L. J., et al: The "H Graft" in Portacaval Shunts. Ann. Surg., 168:201, 1968.
27. Nay, H. R. and Fitzpatrick, F. H.: A Study of Various Types of Superior Mesenteric Vein-Inferior Vena Cava Shunts Via Composite Vein Grafts. Surgery, 59:540, 1966.
28. Orloff, M. J.: Emergency Portacaval Shunt: A Comparative Study of Shunt, Varix Ligation and Non-surgical Treatment of Bleeding Esophageal Varices in Unselected Patients with Cirrhosis. Ann. Surg., 166:456, 1967.
29. Preston, F. W. and Trippel, O. H.: The Technique of Emergency Portacaval Shunt. Surg. Clin. North Am., 46: 37, 1966.
30. Read, R. C., Thompson, B. W., Wise, W. S. and Murphy, M. L.: Mesocaval H Venous Homografts. Arch. Surg., 101: 785, 1970.
31. Read, R. C.: Personal Communication.
32. de Resende Alves, J. B.: Operacao de Escolha No Tratamento da Hipertensao Portal. J. Brasiliero de Cirurgia, 2:1061, 1963.
33. Reynolds, J. T. and Southwick, H. W.: Portal Hypertension: Use of Venous Grafts when Side to Side Anastomosis is Impossible, Arch. Surg., 62:789, 1951.
34. Symbas, P. N., Foster, J. H. and Scott, H. W., Jr.: Late Behavior of Portal Vein Grafts. Surg. Forum, 13:322, 1962.
35. Theron, P.: Portacaval Shunt Operations with Special Reference to the Use of Vein Grafts. S. Afr. Med. J., 27:73, 1953.
36. Turcotte, J. G., Wallin, W. W., Jr. and Child, C. G.: End-to-Side Versus Side-to-Side Portacaval Shunts in Patients with Hepatic Cirrhosis. Am. J. Surg., 117:108, 1969.
37. Warren, W. D., Fomon, J. J. and Zeppa, R.: Further Evaluation of Selective Decompression of Varices by Distal Splenorenal Shunt. Ann. Surg., 169:652, 1969.
38. Warren, W. D., Zeppa, R. and Fomon, J. J.: Selective Transsplenic Decompression of Gastroesophageal Varices. Ann. Surg., 166:437, 1967.
39. Yeoh, K. S. and Eiseman, B.: Portal Vein Thrombosis: Thrombectomy and Portacaval Anastomosis with the Use of a Graft. Singapore Med. J., 3:64, 1962.

Discussion

Dr. Gilbert S. Campbell (Little Rock): At last year's meeting Dr. Francis Jackson reported that a randomized study of portacaval decompression in the treatment of veterans bleeding from esophageal varices demonstrated increased survival with this procedure. However, such patients are bad surgical risks, and at our Veterans Hospital in Little Rock Drs. Raymond Read and Bernie Thompson have tried to reduce operative mortality by simplifying the procedure.

At the vascular society meeting 2 years ago they presented their results in eight patients undergoing mesocaval interposition with vena caval homografts. The number of consecutive operations now totals eighteen. Recently, the patient's own jugular vein has been used to avoid relying on autopsy material.

Drs. Read and Thompson are pleased with their results, which, however, are not as good as Dr. Drapanas'. Three patients died in the early postoperative period, one from pancreatitis following passage of the graft above the duodenum, a route no longer used, another of liver failure, and the last one from bleeding and perforated stress ulceration of the duodenum. Two of the 15 long-term survivors ultimately died some months later of hepatoma. Both grafts were open. One other patient succumbed from pneumonia 2½ years postoperatively. His homograft was also patent.

The remaining 12 patients have been followed for up to 3½ years. Only one has re-bled, and on gastroscopy was found to have alcoholic gastritis. Nine survivors have had postoperative splenoportograms. Grafts were patent in eight or nine. Hepatic encephalopathy has not been a problem, as Dr. Drapanas has mentioned.

[Slide] This slide will show what I think is the best technic, that of interposition of the jugular vein autograft between the vena cava and the portal vein; it could also be interposed between the vena cava and the superior mesenteric vein.

I think both Drs. Read and Thompson endorse the concept of interposition mesocaval shunt in the treatment of bleeding from portal hypertension. However, we believe that homografts or, even better, an autograft vein is preferable on the basis of previous experimental studies in animals, and our own experience with early patency.

So today, at least, we would electively use a jugular vein autograft for the mesocaval interposition.

Dr. Jere W. Lord, Jr. [New York]: To bring Dr. Drapanas' data into perspective, there were two deaths in 25 patients postoperatively. Dr. Child in 1969 reported on his experience with end-to-side portacaval shunts. In 80 patients in the "B" and "C" groups there was a 28% mortality, three times that of Dr. Drapanas' procedure, and in the "C" group alone there were two deaths in Dr. Drapanas' twelve, or 17%, whereas in Child's there were 18 deaths in 34, a 53% mortality; again, a three-to-one figure.

There may be many reasons to account for this, but I think the most obvious is that the operation is simpler, takes a shorter time, less blood is lost, and less anesthesia is needed. There may be other factors too.

The second important thing that Dr. Drapanas has settled: Many surgeons have asked whether these prostheses would stay open in the venous system, and he has reported on 15 long-term studies by angiography, and all 15 prostheses were patent one year or longer.

From July, '66 to December, '71 our group has operated on 25 patients, and of these, 13 followed a year or longer, 11 were proven to be patent. One closure was due to a technical failure, proved at autopsy with an inadvertent suturing of both walls of the prosthesis, which is not recommended. The other patient whose prosthesis closed, was patent one month postoperatively by angiography. He returned a year later because of massive hemorrhage. The angiogram showed it to be closed. He was subjected to a portacaval shunt, with a successful outcome. We do not understand why that happened.

Of these two groups, 26 of 28 prostheses were patent. We have used Teflon. Dacron has been the best thing in Dr. Drapanas' hands. It probably makes little difference.

The final point that Dr. Drapanas has made, and we agree heartily, is that one should avoid emergency shunts in these patients. In 12 of his patients, according to the data I gleaned from his paper, there were two deaths. In the 13 elective operations there were none. In our 14 emergency operations there were six deaths in the first 6 weeks postoperatively, and there were no deaths in the 11 elective ones.

For this reason, we believe that one should do everything possible on a conservative basis to control the hemorrhage, and then a few days later, a week or so, carry out an elective procedure.

Dr. W. Dean Warren (Atlanta): I would hasten to say that I disagree with one of Dr. Drapanas' conclusions, namely, that there has been continued perfusion of the liver following the