

Fifty Years of Surgery for Portal Hypertension at the Cleveland Clinic Foundation

Lessons and Prospects

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Objective

The 50-year experience with surgery for the treatment of portal hypertension and bleeding varices at the Cleveland Clinic is reviewed.

Summary Background Data

A variety of procedures have been used to treat bleeding varices during the past 50 years. These include transesophageal ligation of varices or devascularization of the esophagus and stomach with splenectomy; portal-systemic (total) shunts; distal splenorenal (selective) shunts; endoscopic sclerotherapy; transjugular intrahepatic portal-systemic shunts; and liver transplantation.

Methods

Our experience with these procedures is reviewed in four time periods: 1946 to 1964, 1965 to 1980, 1980 to 1990, and 1990 to 1994.

Results

Our use of these procedures has changed as experience and new techniques for managing portal hypertension have evolved. Most ligation—devascularization—splenectomy procedures were performed before 1980; they provide excellent results in patients with normal livers and extrahepatic portal venous obstruction, but a major complication (40–50%) is rebleeding. Total shunts were performed most frequently before 1980; with patient selection, operative mortality was reduced to 8%, control of bleeding was achieved in more than 90%, but the incidence of encephalopathy was high (30%). Selective shunts provide almost equal protection from rebleeding with less post-shunt encephalopathy. We currently use selective shunts for patients with good liver function. Liver transplantation has been used since the mid 1980s for patients with poor liver function and provides good results for this difficult group of patients.

Conclusions

The selection of patients for these procedures is the key to the successful management of portal hypertension.

It has been almost 50 years since the first reports of Whipple¹ and of Blakemore and Lord^{2,3} from the Spleen Clinic at Columbia University in 1945, when the use of portacaval shunts for the treatment of portal hypertension was introduced. In 1950, Dr. George Crile, Jr., from the Cleveland Clinic, published the first report on transesophageal ligation for bleeding esophageal varices.⁴ During these early years, from 1945 through the 1950s, transesophageal ligation of varices, gastric devascularization with splenectomy, and portacaval shunts all began to be performed for patients with portal hypertension and bleeding esophagogastric varices at the Cleveland Clinic.

In 1957, Dr. Richard Britton came to the Cleveland Clinic from Columbia University to focus on the problem of bleeding varices from portal hypertension. He and Crile subsequently reported on the late results of transesophageal ligation procedures in 28 patients.⁵ During these years, 1946 to 1962, an increasing experience with portacaval shunts continued. In 1962, the senior author (REH) replaced Dr. Britton in the Department of General Surgery and, in 1965, we reviewed our initial experience with portal-systemic shunts, reporting 76 procedures.⁶ We subsequently have continued to follow and document our experience at the Cleveland Clinic with surgery for portal hypertension in a series of reports.⁷⁻¹⁴

In the 1980s, endoscopic sclerotherapy was reintroduced and popularized as a potentially safer method for controlling bleeding esophageal varices.^{15,16} As this non-operative method of managing varices began to be used more frequently, the use of surgical methods decreased during the 1980s. During this time period, studies and reports from Warren and associates at Emory University convinced many surgeons that selective shunts were superior to total shunts.¹⁷⁻¹⁹

In the latter half of the 1980s and into the 1990s, liver transplantation became a real treatment option and is the most effective treatment for portal hypertension in patients with end-stage liver disease.²⁰ Also, since 1991, the transjugular intrahepatic portal-systemic shunt (TIPS) has been developed.²¹ This nonoperative shunt procedure is being used for selected patients, either at high risk for surgery or to prevent repeated hemorrhages before liver transplantation.

A common theme in the surgical history of portal hypertension at the Cleveland Clinic has been patient selection. For the options available at any given time over

these years, it has been apparent that outcome is determined by appropriate patient selection. This is as true today as it was when Dr. Crile embarked on managing these patients in the 1940s. This manuscript reviews the evolution of our experience with these various procedures for portal hypertension, during the past 50 years, to attempt to place into perspective the lessons we have learned from this experience and to guide us in the future.

CLINICAL MATERIAL

The Early Years: 1946-1964

During the first 18 years of experience, transesophageal ligations, gastric devascularization, and splenectomy were performed predominantly for two groups of patients: 1) a low-risk group with normal livers who had splenic or portal vein thrombosis with cavernous transformation of the portal system and 2) a high-risk group—patients with failed prior portal-systemic shunts and patients with poor liver function—in whom a shunt procedure was deemed hazardous. Crile's report in 1950, along with that of Boerema²² from Holland, were the first reports of direct ligation of bleeding esophageal varices in the literature. An example of the type of patient Crile was treating in those days comes from his first report:

"The patient was an unmarried woman 23 years of age. Hematemesis occurred at age 13 and the spleen was removed at age 16 for congestive splenomegaly. She had received injections of esophageal varices 60 times and transfusions 124 times and had been admitted to the hospital 60 times. The stomach had been completely devascularized and transected . . . the vagus nerves had been divided . . . a subdiaphragmatic abscess on the left side had been drained . . . exsanguinating hemorrhages were occurring at intervals of 2 to 4 weeks."⁴

Dr. Crile chose to avoid the abdomen and performed a transthoracic transesophageal ligation of the varices. The patient survived and 1½ years later, bled from a gastric ulcer. This was treated medically, and the patient survived without further hemorrhage during follow-up of 12 years.

Table 1 gives the results of this initial ligation/devascularization, splenectomy experience. It is clear that patients with cirrhosis had a higher operative mortality, a greater incidence of rebleeding, and a higher late mortality than patients with normal livers and prehepatic block. Based on this experience, we began to perform portal-systemic shunts for most patients with portal hypertension due to cirrhosis. All shunts during this period of time were total shunts, either end-side or side-side portacaval shunts, mesocaval shunts, or central splenorenal shunts.

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Table 1. SURGERY FOR PORTAL HYPERTENSION CCF—EARLY YEARS 1946–1964

Procedure	Patients	Operative Mortality	Rebleeding	Encephalopathy	5-Yr Survival
Esophageal ligation/ devascularization/ splenectomy	n = 28 Normal liver, PVT 14 Cirrhosis 14	0 43%	29% 36%	—	93% 36%
Portal-systemic shunts	n = 76	26%			
PC 68	Child A/B 53	17%	16%	33%	45%
MC 3	Child C 23	48%			
SR 5					
76					

PVT = portal vein thrombosis; PC = portacaval; MC = mesocaval; SR = splenorenal.

Table 1 also reviews our experience with the first 76 patients having portal-systemic shunts during these early years. Of this group, 68 patients had portacaval, 3 patients had mesocaval, and 5 patients had central splenorenal shunts. An analysis of morbidity and mortality in these patients showed that patients with good hepatic function (Child A/B) and those having elective shunts, rather than an emergency procedure, had lower operative mortality than patients with poor hepatic function (Child C) or those in whom the shunt had to be performed as an emergency because of uncontrolled or continuing hemorrhage. Operative mortality in poor-risk and emergency patients appeared to be excessive. This early experience convinced us that, whenever possible, selection of patients based on adequacy of liver function was essential in the planning of a major shunt procedure in patients with cirrhosis. We also tried, whenever possible, to avoid emergency shunts, to control variceal hemorrhage nonoperatively, and to plan an elective shunt.

The Selection of Patients: 1965–1980

During the next 15 years, 1965 to 1980, we began to select patients for shunt operations, avoiding shunt operations in patients with poor liver function or in whom emergency procedures were necessary. In these patients, every attempt was made to control bleeding by the use of a Sengstaken-Blakemore tube (Davol, Inc., Providence, RI),⁹ by vasopressin infusion, or when necessary, by a limited emergency operative procedure consisting of high gastrotomy, oversewing of gastric varices, end-to-end stapling obliteration of esophageal varices, and ligation of the left gastric vein. Patients were treated medically to improve liver function before the planning of an elective portal-systemic shunt.

Several subsequent reports document our efforts in this regard.^{10,11,14} Table 2 gives the results we achieved during this time period. Operative mortality for patients

having ligation or devascularization procedures continued to demonstrate good survival for patients with portal vein thrombosis and a normal liver (5-year survival—75%), whereas those patients with cirrhosis had a higher operative mortality and a 5-year survival of only 40%. Rebleeding was high in both groups, averaging 47%, and encephalopathy was seen only in patients with cirrhosis.

In patients having shunt surgery, the operative mortality in good-risk patients—the majority of patients selected for surgery—improved to 9%, whereas operative mortality in poor-risk patients remained high, at 36%. Our overall operative mortality was 13%. A limited number of emergency shunts were performed during this time period and, in these patients, operative mortality remained considerably higher (60%) than in patients who underwent operations electively. Overall 5-year survival improved to 54%, with a 10% incidence of rebleeding and a 22% incidence of encephalopathy.

The Sclerotherapy Decade: 1980–1990

In the 1970s, endoscopic sclerotherapy was reintroduced when flexible fiberoptic technology became readily available. By the 1980s, this was being widely used with success in controlling acute bleeding and preventing early recurrent bleeding. Sclerotherapy became our first choice of treatment for portal hypertension during this decade and with its increased use to control variceal hemorrhage, the incidence of—or need for—operative management for most patients with portal hypertension declined. In the 1980s, more than 500 patients had endoscopic sclerotherapy as primary management at the Cleveland Clinic.

The surgical cases in the 1980s fell into two groups. Sixty-six patients had liver transplantations, and 49 patients had shunts or devascularization. These 49 patients are summarized in Table 3. They all had failed sclerotherapy. There were only 18 good-risk patients with cir-

**Table 2. SURGERY FOR PORTAL HYPERTENSION CCF—
SELECTION OF PATIENTS 1965–1980**

Procedure	Patients	Operative Mortality	Rebleeding	Encephalopathy	5-Yr Survival
Esophageal ligation/ devascularization/ splenectomy	n = 78 Normal liver, PVT 40 Cirrhosis 38	15% 36%	50% 40%	10%	75% 40%
Portal-systemic shunts	n = 188	13%			
PC 116	Child A/B 163	9%	10%	22%	54%
SR 26	Child C 25	36%			
MC 21					
DSRS 25					
188					

PVT = portal vein thrombosis; PC = portacaval; MC = mesocaval; SR = splenorenal; DSRS = distal splenorenal shunt.

rhosis or extrahepatic portal vein thrombosis who received elective operations, primarily distal splenorenal shunts (DSRS) or devascularizations. We began to note that many patients who failed sclerotherapy showed progression of their liver disease with recurrent bleeding and were higher-risk patients when they came to operation.

The outcome of patients in this decade is summarized in Table 3; it shows an overall hospital mortality that had increased to 27% and a 5-year survival of only 39%. The results in the better risk DSRS group were slightly better than in the poorer-risk devascularization and total shunt patients.

Rebleeding in the devascularization group was similar to prior experience, at 45%. In the two shunt groups, early shunt thrombosis was seen in four DSRS patients and three total shunt patients, was associated with rebleeding in all patients, and resulted in hospital mortalities for six of these patients. Rebleeding after hospital discharge occurred in one (6%) DSRS patient and two (20%) mesocaval shunt patients.

Encephalopathy of any degree after hospital discharge was documented in 4 of 18 evaluable DSRS patients and 4 of 10 evaluable total shunt patients. The majority of survivors in the devascularization group had normal livers and showed no encephalopathy.

The poorer results of this decade compared with our experience in the 1970s reflects patient selection. Almost all of the patients coming to operation during this decade were selected on the basis of their continued bleeding rather than for being good candidates for surgical intervention.

The 1990s—Selective Shunt/TIPS/ Transplant

In the 1990s, patient selection again has become an important issue in making decisions on management of patients with variceal bleeding. Sclerotherapy has remained the primary therapy for acute bleeding and the initial management to prevent recurrent bleeding. However, when variceal bleeding continues to reoccur, rather than persisting with sclerotherapy, we now favor one of the three options of liver transplantation, selective shunt, or TIPS procedure. Our experience with these three options is summarized in Table 4.

Total shunts have almost disappeared from the operative repertoire, largely because of the use of TIPS as the total shunt of choice at this time. Three operative total shunts have been done in the 1990s, with one mortality. Devascularization still plays a minor role in surgical

**Table 3. SURGERY FOR PORTAL HYPERTENSION CCF—
THE SCLEROTHERAPY DECADE 1980–1990**

	No. of Patients	Child's Class			Hospital Mortality	Rebleeding	Encephalopathy	5-Yr Survival
		A	B	C				
DSRS	23	10	8	5	22%	22%	22%	38%
Total shunts	15	3	6	6	33%	26%	40%	27%
Devascularization	11	5	1	5	33%	45%	—	45%

Table 4. SURGERY FOR PORTAL HYPERTENSION CCF—SELECTIVE SHUNTS, TIPS AND TRANSPLANTATION 1990–1994

	Number of Patients	Child's Class			Hospital Mortality	Rebleeding	Encephalopathy	Survival
		A	B	C				
DSRS	33	28	5	0	0	3%	6%	97% (1-yr)
TIPS	41	7	14	20	22%	29%	31%	44% (1-yr)
OLT*	66	10	30	26	12%	0	0	72% (5-yr)

* Patients with prior variceal bleeding.

TIPS = transjugular intrahepatic portal-systemic shunt.

management, with four such operations in the 1990s to date. These are reserved for patients with extensive venous thrombosis in whom other nonsurgical methods of controlling bleeding have failed.

Distal splenorenal shunts were performed in 33 patients between 1990 and 1994. All were Child's Class A or B; 45% of the patients had alcoholic liver disease, and the others had a variety of nonalcoholic etiologies for their portal hypertension. Two patients had extrahepatic portal vein thrombosis. In this highly selective group of patients, there was no hospital mortality and only one death due to a myeloproliferative disorder at 9 months. One patient had early rebleeding at 1 week, his shunt was open, and bleeding was controlled with conservative methods. He has not rebled. One patient with portal vein thrombosis and a myeloproliferative disorder thrombosed his shunt in the first week, and was treated by splenectomy and devascularization, even though he did not rebleed. The overall control of variceal bleeding with DSRS has been 97%. Encephalopathy, controlled with diet and lactulose, has been observed in two patients at a median follow-up of 16 months.

Transjugular intrahepatic portal-systemic shunt was introduced in this experience in 1991. This has been attempted in 45 patients and has been successfully placed in 41 patients. The 41 patients are profiled in Table 4. Clearly, this is a different population than the DSRS patients, with 83% Child's B or C. The hospital mortality in this group was 22%, with nine subsequent deaths at current follow-up, for an overall survival of 44%. In the majority of these patients, TIPS was used emergently, and bleeding control during the initial hospitalization was achieved in 90%. Variceal rebleeding occurred in 8 of 32 discharged patients, for a rebleeding rate of 25% in this at-risk group. Considering both early and late rebleeding, the overall rebleeding rate was 29%. Encephalopathy has occurred in 10 of the 32 patients who left the hospital, for an overall rate of 31%. Three of these patients had documented encephalopathy before TIPS, giving a post-TIPS encephalopathy rate of 22%. Three patients from

this group have had liver transplantation, and five others are awaiting transplant. Transjugular intrahepatic portal-systemic shunt was used as a deliberate treatment choice as a "bridge" to transplant.

The liver transplant experience at the Cleveland Clinic Foundation totals 242 transplants in 230 patients since 1984; 66 transplants were performed in the 1980s, and 176 were performed since 1990. The indication for liver transplant has been end-stage liver disease, but parallel with most series, 30% of the patients having transplants have had variceal bleeding as a component of their disease. The profile and outcome of the 66 patients with a history of variceal bleeding over the total experience is summarized in Table 4. Hospital mortality was 12%, with a 5-year survival of 72%. No patients rebled from varices or had hepatic encephalopathy. Survival analysis of the patients with variceal bleeding compared with those without shows no significant difference in outcome. One-year survivals are 80% and 78%, respectively and 5-year survivals 72% and 63%. Liver transplantation currently provides surgeons with a technique to successfully manage those patients who had the worst outcomes after portal-systemic shunts—patients with poor liver function.

Cost comparisons of patients treated in 1993 by DSRS, TIPS, or orthotopic liver transplantation were made and are summarized in Table 5. The TIPS patients fell into two distinct groups: five low-risk patients with median charges of \$14,000 and nine high-risk patients with a median charge of \$55,000. The overall hospital charge data for DSRS, TIPS, and liver transplants must be interpreted in light of the very different patient groups managed by these methods, as profiled in Table 4.

Our overall experience with surgery for portal hypertension during the past 50 years includes (Fig. 1) 121 patients who had esophageal ligation or gastric devascularization procedures, almost always with splenectomy; 338 patients who had decompressive shunts—257 of which were total portal-systemic shunts and 81 of which were selective shunts; 41 TIPS procedures; and 66 patients

Table 5. MEDIAN HOSPITAL CHARGES FOR DSRS, TIPS, AND OLT AT CLEVELAND CLINIC FOUNDATION—1993

	No. of Patients	Median LOS	Median Hospital Charge
DSRS	17	10 days	\$23,000
TIPS	15	11 days	\$27,600
OLT	37	22 days	\$95,000

DSRS = distal splenorenal shunts; TIPS = transjugular intrahepatic portal-systemic shunt; OLT = orthotopic liver transplantation.

who had liver transplantation with a history of variceal bleeding in a total experience of 242 liver transplants.

DISCUSSION

This experience chronicles the history of surgery for portal hypertension from the mid 1940s to the mid 1990s. Most of the surgical procedures introduced in this half-century to treat portal hypertension have been used at the Cleveland Clinic and parallel the changes in management and the lessons learned from other centers.

Ligation and devascularization procedures had an overall rebleeding rate of 40% to 50% in this experience, which is similar to other reported North American experience.²³ Better rebleeding control has been achieved by the Japanese²⁴ and in a recent series from Mexico.²⁵

Control of variceal bleeding is best achieved by variceal decompression, which can be achieved in several ways. Total portal-systemic shunts provided excellent control of bleeding (90%) in this experience, similar to other reported experiences.^{18,19,27} Selective shunts

(DSRS) also provided good control of bleeding overall in 90% of patients, which parallels other reported experiences.^{17,18,19} Transjugular intrahepatic portal-systemic shunts can provide good initial control of bleeding in difficult patients, as shown in this review; however, in this experience, as in others,^{28,29} the risk of stenosis/thrombosis and rebleeding is high. Liver transplantation is an excellent way to decompress varices, but it is end-stage liver disease, rather than the bleeding, that is the indication for this procedure.²⁶

Control of bleeding is only one part of the total picture for these cirrhotic patients. Although bleeding is a major life-threatening problem, the selection of treatment also must take into account hepatic function, the operative risk, and the risk of accelerating encephalopathy and liver failure.

Encephalopathy has two major etiologic components, poor liver function and portal-systemic shunting. In this experience, encephalopathy was not documented in any patients with normal livers and extrahepatic portal hypertension, regardless of which operation they received. Other series have documented subclinical³⁰ or overt³¹ encephalopathy in this population at late follow-up (>10 years) after total portal diversion. In patients with cirrhosis, both of the above etiologic factors contribute, with the degree of shunting differing, depending on the operative method used to manage their bleeding. This series documented the lowest encephalopathy after ligation/devascularization procedures (10%), followed by DSRS (13%), and the greatest after total shunts (22–40%). Encephalopathy was not seen after liver transplantation. These findings parallel other reported series,^{18,19,25} but clearly, the rate of encephalopathy is a function of patient selection before operation and the intensity of looking for it at follow-up. In this retrospective review, the occurrences reported probably reflect the lowest rate.

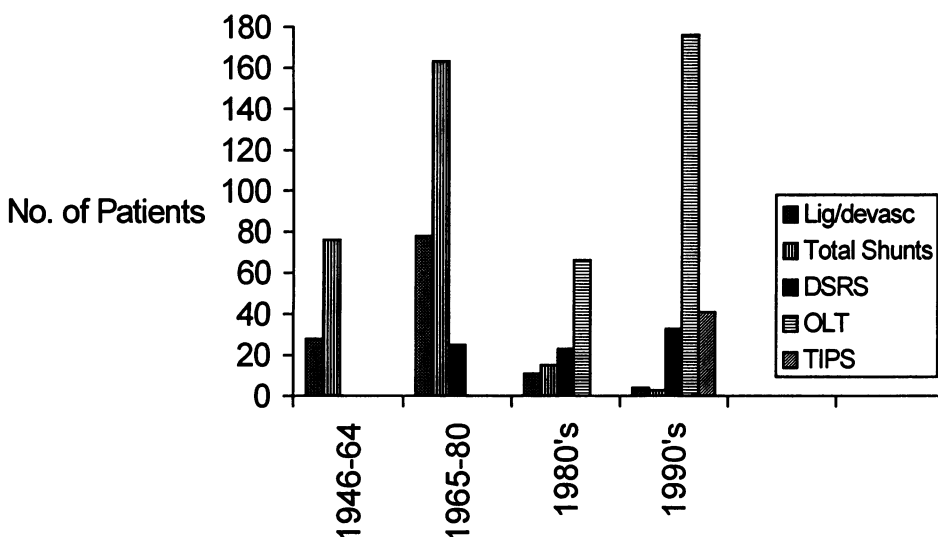


Figure 1. Surgery for portal hypertension—the Cleveland Clinic, 1945–1994. This chart compares the number of patients having procedures for portal hypertension during each of four time periods: 1946–1964, 1965–1980, 1980–1990, and 1990–1994.

Survival can be assessed at two time points—operative mortality and late survival. Operative mortality is mainly a function of patient selection, which is demonstrated in two settings in this review. First, the total shunt experience in the pre-1965 era compared with the 1965–1980 years showed that by operating on better-risk patients and avoiding emergency shunts, operative mortality could be reduced from 26% to 13%. Second, operative mortality for DSRS was low in the pre-1980 “selection era” at 8%, and has been 0% in the 1990s; however, it rose to 22% in the 1980s, when the main selection factor was continued bleeding after sclerotherapy. The lesson from this experience is that an acceptably low operative mortality can be achieved by appropriate preoperative evaluation/selection.

Late survival may be influenced by the underlying disease, by the treatment given or by unrelated factors. The contributions of each of these can be difficult to differentiate. In this series, patients with noncirrhotic portal hypertension had the best long-term survival. For the patients with cirrhosis, the selection of better risk patients for operation resulted in better late survival for those having total shunts in the 1965–1980 era compared with the pre-1965 era. Equally, patients having DSRS in the pre-1980 and post-1990 eras, when selection was more stringent, had better late survival than those having DSRS in the 1980s.

Analysis of late survival for patients with or without variceal bleeding going to liver transplant was performed to address conflicting data in the literature. The Pittsburgh group reported³² significantly better survival in their patients who had a history of variceal bleeding before transplant compared with those who did not. In contrast, the Emory experience³³ showed significantly worse outcome in those with a history of prior variceal bleeding. These two sets of data could be interpreted as one center offering transplant early to this set of patients, whereas the other offered it late. Analysis of the data in this series shows an identical outcome in these two Cleveland Clinic patient subsets, with and without variceal bleeding, which we interpret as indicating that this event was not a major factor in the decision to proceed to transplant.

The cost of managing patients with variceal bleeding is high, regardless of which treatment modality is used, and must be taken into account in developing overall strategies. The data in this paper are only a single snapshot indicating the median hospital charges for the disparate subsets of patients that we currently are selecting for DSRS, TIPS, and transplant. Few data on the cost of managing such patients are available in the literature,^{33–35} but should be included in future trials and series analysis. Cost must look beyond the hospital procedure, e.g., as shown by Rikkers et al., who documented that at 2 years, the charges

for managing patients by DSRS and sclerotherapy were equivalent.³⁴ The other endpoint of return to work and quality of life have impact on cost issues and have not been addressed in any studies. No specific conclusions can be drawn from the charge data in this paper. They are presented to act as a stimulus to other groups to look at this variable.

The Prospects

The goals in managing patients with portal hypertension and variceal bleeding are:

- Stop the bleeding (permanently).
- Do not precipitate/accelerate encephalopathy or liver failure.
- Achieve long-term survival.

In the 1990s, there are more treatment options than ever for these patients, and we must learn to use them optimally. A major theme from this review of a half-century of experience is the importance of patient selection. How is that best achieved? It is best achieved by full evaluation of the patient. The important issue of liver function and the need or suitability for liver transplantation should be evaluated early. This influences other management decisions. In patients with normal livers or with good liver function, management emphasis should be on control of bleeding and variceal decompression. In patients with poor liver function, management emphasis should be on liver transplantation. Our experience over the past 50 years has documented how treatment options have changed. Selection of patients and of procedures is the key to the successful management of patients with portal hypertension.

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Discussion

DR. ATEF A. SALAM (Atlanta, Georgia): Dr. McDonald, Dr. Copeland, Members and Guests. This most enjoyable paper puts in a historical perspective the evolution of surgical treatment of portal hypertension over the past 50 years. It chronicles the experience of the Cleveland Clinic, an institution which has hosted and still hosts some of the most outstanding leaders in the field. Like good historians, the authors do not limit themselves to documenting the rise and fall of various therapeutic modalities, but they give us a very thoughtful analysis of the reasons why these major shifts took place. They address rebleeding as a major disadvantage of variceal ligation and gastric devascularization, postshunt encephalopathy as a major cause of morbidity after total shunts, and the efficacy of selective shunts as a means to avoid this complication. They also give us their views regarding sclerotherapy as the preferred method for the primary management of variceal bleeding and selective shunting as the recommended procedure for patients who fail sclerotherapy provided they have adequate liver reserve. Finally, they bring us up to date on the role of TIPS and liver transplantation in patients with severe liver disease in whom injection therapy fails to control the bleeding.

One theme which is appropriately emphasized by the authors is the importance of patient selection for the various options that are currently available for the prevention of recurrence of variceal bleeding. The criteria outlined by the authors in this regard are very similar to those adopted at Emory. This is not surprising because Dr. Henderson was instrumental in defining these criteria during his tenure in Atlanta before moving to Cleveland.

I have the following five questions for the authors: What criteria do they currently use to declare failure of sclerotherapy? How do they manage gastric varices? Sohandra in Germany reports excellent results treating them with histoacryl injection. Have the authors had any experience with this technique? At present, we feel that TIPS are useful as a bridge in patients who bleed while awaiting transplantation. Some radiologists and gastroenterologists are advocating a larger role for the technique. What are the authors' indications for TIPS at present? If we look at portal hypertension as we look at the economy nowadays, from a global perspective, what would the authors recommend for the treatment of variceal bleeding in developing nations? There transplantation is hardly available and TIPS are rarely utilized, particularly in view of the expenses involved and questionable long-term benefits. Finally, did portal vein