Portacaval H-Graft: Relationships of Shunt Diameter, Portal Flow Patterns and Encephalopathy

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Small-diameter protacaval H-grafts, 10, 12, or 14 mm, were constructed in 29 cirrhotic patients with previous or active variceal hemorrhage. When 10 mm grafts were used in combination with portal collateral outflow ligation, varying degrees of prograde portal flow were maintained in 50% of the patients. When shunt size was greater, prograde flow was lost in more than 90%. The incidence of spontaneous postoperative encephalopathy was 11% in patients with prograde flow, compared with 50% in those with retrograde flow ($p = 0.05$). It is concluded that maintaining prograde portal flow after portacaval shunt is essential in minimizing postoperative encephalopathy. Prograde portal flow may be achieved in 50% of patients using 10 mm PTFE portacaval H-grafts combined with portal collateral ligation.

UNIVERSAL AGREEMENT has not been reached regarding the importance of prograde portal flow in minimizing portasystemic encephalopathy (PSE) after portacaval shunt. Thus, while Warren, Zeppa, and others[1-3] have shown this relationship for distal splenorenal shunt, Bismuth and his coworkers,[4] studying small-diameter direct side-to-side portacaval shunts and proximal splenorenal shunts, found no relationship. The latter study however is controversial, since stomal sizes may have been too large to permit prograde portal flow, veno-venous anastomoses may have expanded with time, and celiac angiography may have indicated hepatic "pseudoperfusion" (retrograde filling of portal radicals via hepatic artery).[5] The authors studied cirrhotic patients undergoing portacaval H-grafts using Dacron or expanded, reinforced polytetrafluroethylene (PTFE), nonexpansile materials in controlled sizes. Postoperative portal hemodynamics were assessed by direct shunt cannulation or superior mesenteric artery (single injection) angiography. Careful assessment of postoperative spontaneous portasystemic encephalopathy was correlated with age, Child's classification, shunt diameter, and portal hemodyanmics.

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Materials and Methods

Since 1980, 29 consecutive patients underwent 12- or 14-mm Dacron portacaval H-grafts (PCHG-12/14), or 10-mm PTFE portacaval H-grafts combined with portal collateral outflow ligation (PCHG-10/CL), including ligation of coronary, gastroepiploic, umbilical, and paraesophageal veins. All patients had alcoholic cirrhosis with previous or active variceal hemorrhage documented by endoscopy. Graft material and diameter were based upon operative considerations, graft availability, and surgeons' preference. Fully informed consent was obtained prior to each procedure. Follow-up data were elicited from patients and relatives during frequent outpatient visits. Only one patient was lost to follow-up nine months after PCHG-10/CL, and he had no evidence of encephalopathy. Mean follow-up was 12.5 (range 6–17) months for PCHG-10/CL patients and 12.9 (range 6–21) months for the PCHG-12/14 group.

Operative risk was classified according to Child[6] immediately prior to operation. Operations were classified as emergency shunts if patients were actively bleeding within eight hours of the procedures. Postoperative angiography (superior mesenteric artery and/or shunt cannulation) was performed within three weeks of operation in 20 patients, and at three to 12 months in an additional seven PCHG-10/CL patients. In order to assess the direction of flow accurately during shunt cannulation studies, small amounts of contrast were hand-injected at the level of portal vein-to-graft anastomoses, and flow patterns were assessed fluoroscopically in 17 patients. The remaining had SMA venous-phase angiography (single-injection).

Patients were considered as having preoperative encephalopathy if they were stuporous or comatose prior to surgery and/or if earlier episodes were documented.

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TABLE 1. *Comparisons of Intraoperative Pressure Measurements*

	Portal Pressure Before Shunt (Cm Saline)	Portal Pressure After Shunt (Cm Saline)	Portal Pressure Reduction (%)	Shunt Gradient (Cm Saline)
PCHG-10/CL	42 ± 8	29 ± 5	30 ± 7	12 ± 2
PCHG-12/14	43 ± 10	20 ± 6	54 ± 10	4 ± 1
p	N.S.	N.S.	<.05	<.01

Results (mean ± S.D.) of intraoperative pressure measurement. In the PCHG-10/CL group, the measurements after shunt are also after collateral ligation. Shunt gradient was defined as the difference between portal pressure and infradiaphragmatic caval pressure with grafts open.

Postoperative PSE was assessed by careful screening of patients during frequent clinic visits, questioning their family members, and investigating all their hospitalizations. Mild PSE was defined by presence of asterixis, forgetfulness, personality changes, and inappropriate behavior associated with elevated serum ammonia levels. Lactulose relieved their symptoms. Severe PSE was defined as confusion or coma requiring hospitalization and intensive medical management. Spontaneous postoperative PSE was diagnosed after patients had recovered from operation and were not receiving medications.

Statistical analyses were made using Student's t-test, Chi square, and Fisher's exact tests, and Wilcoxon Mann–Whitney test with tied midranks.

Results

Of the 29 patients studied, two died of liver failure within 30 days following emergency operation (operative mortality of 7%). These patients were excluded from further consideration in the studies. The distribution of patients according to Child's criteria was similar to the two groups. Of the 16 surviving PCHG-10/CL patients, there were six (38%) in Child's A Category, eight (50%) in Category B, and two (13%) in Category C. Of the 11

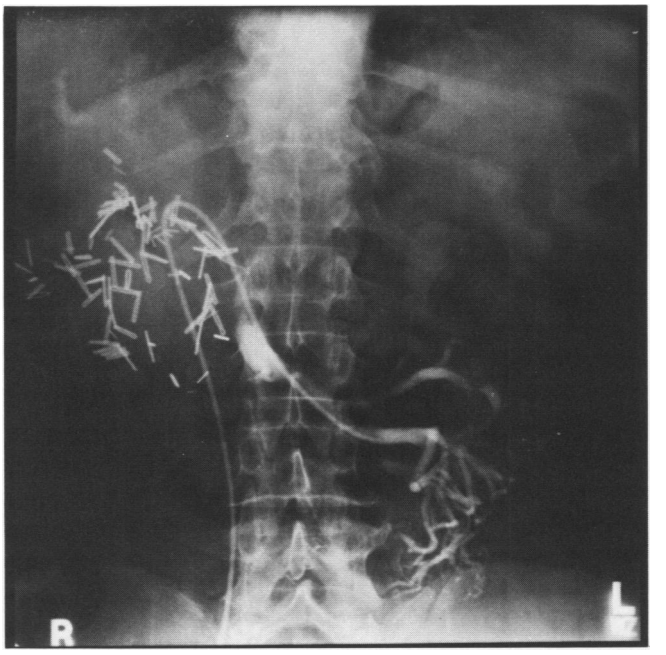

FIG. 2. Delayed phase angiogram of patient shown in Figure 1, demonstrating slow egress of contrast out of the intrahepatic radicals in a prograde direction.

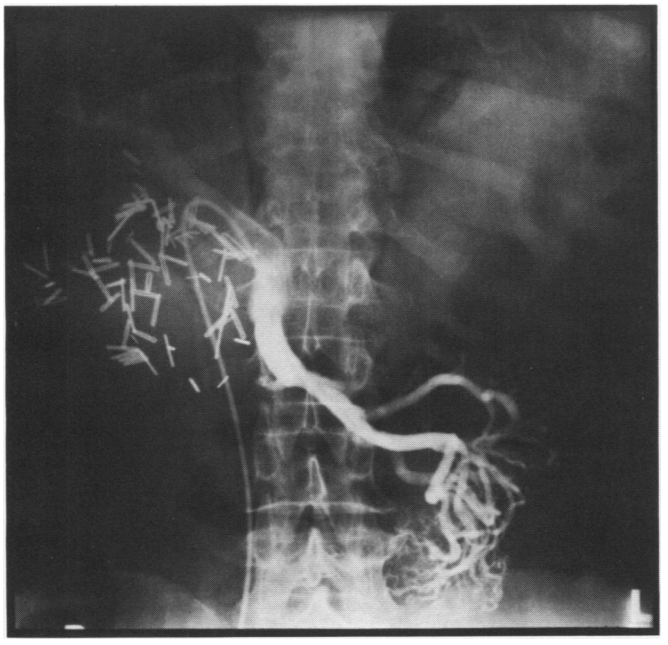

FIG. 1. Minimal filling of intrahepatic radicals, with only primary and secondary radicals visualized following injection of contrast into a peripheral mesenteric tributory.

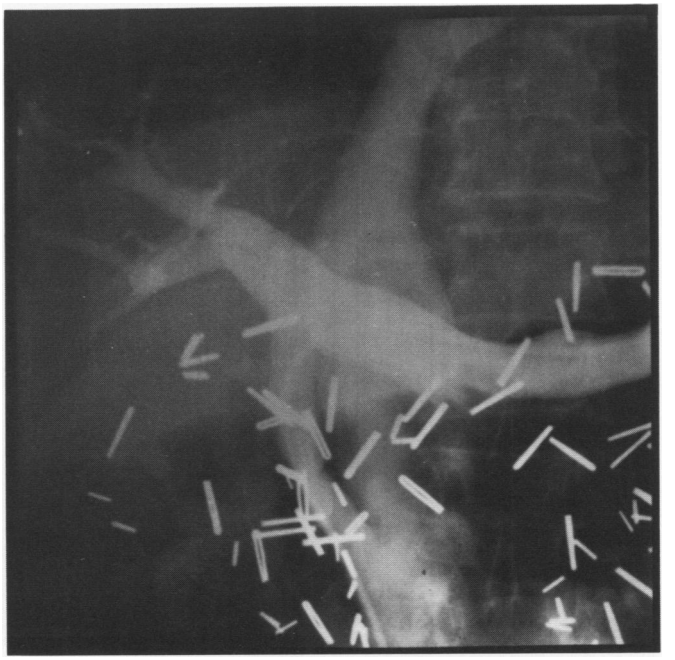

FIG. 3. Moderate filling of intrahepatic radicals, with tertiary branches visualized.

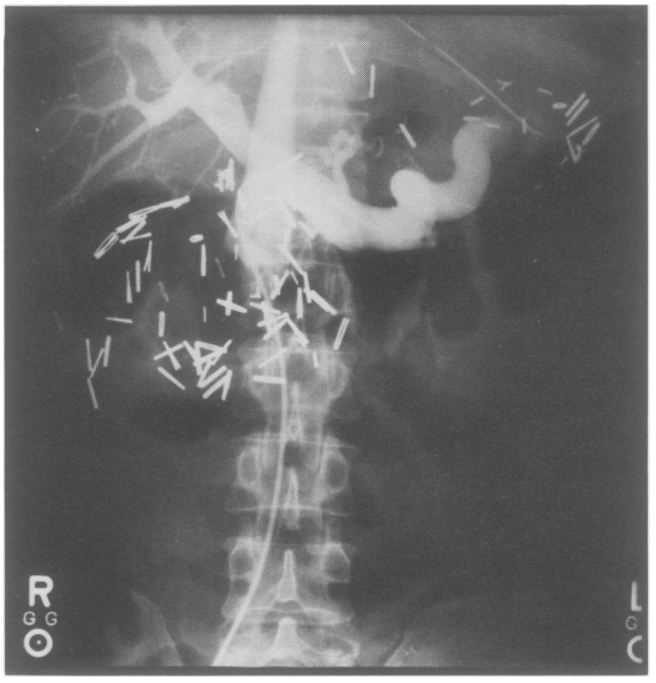

FIG. 4. More extensive visualization of intrahepatic portal radicals, beyond the tertiary levels. Note persistence of distal coronary vein.

PCHG-12/14 patients, five (45%) were in Categories A and B each, and one (9%), Category C. In the PCHG-10/CL group eight (50%) were emergencies, while six (55%) of the PCHG-12/14 group were emergencies.

FIG. 5. Maximum visualization of intrahepatic radicals following PCHG-10/CL. Note large unligated collateral (draining into intercostal system).

Operative Complications

In the PCHG-10/CL group, three required perioperative shunt revision because of PTFE graft kinking. Graft occlusion was suspected by rapidly increasing ascites and was confirmed by angiography. All shunts were successfully revised at immediate reoperation and were subsequently proven patent. An additional patient rebled from a gastric ulcer two weeks following PCHG-10/CL and was successfully treated by subtotal gastrectomy. After operation his shunt was patent as ascertained by angiography. An additional patient had colon perforation within one week of operation, treated successfully by colostomy. His shunt was also proven patent after the latter procedure. Finally, one patient in the PCHG-10/CL group died as a result of a perforated ulcer seven months after operation. His shunt was patent at autopsy. In the PCHG-12/14 group none has required shunt revision.

No patient has rebled from varices, although one patient in the PCHG-12/14 group had a minor gastrointestinal bleed 12 months after operation and the source was not established. His shunt was patent and portal and splenic venous pressures were normal at shunt cannulation. No patient has had refractory ascites after successful PCHG.

Intraoperative Pressure Measurement

The comparisons of intraoperative pressure measurements are summarized on Table 1. The PCHG-10/CL group had significantly higher shunt gradients (portal pressure minus caval pressure, shunt open), and lesser reductions of portal pressures. In these patients collateral ligation resulted in increase of shunt gradients from 8 $\pm$ 2 cm saline to 12 $\pm$ 2 cm ($p < 0.05$).

Postoperative Angiography

In the PCHG-10/CL group, eight (50%) had prograde flow, compared with only one of the PCHG-12/14 group ($p = 0.03$). Several patterns of prograde portal flow were demonstrated as illustrated in Figures 1–6. Two patients exhibited minimal prograde flow as evidenced by slow forward intrahepatic flow of contrast (hand-injected via the shunts). They filled only primary and secondary radicals after mesenteric or splenic venous injection (Figs. 1, 2). Moderate flow was seen in two patients where tertiary branches filled, but smaller radicals were not visualized (Fig. 3). In two patients portal radicals filled beyond the tertiary levels, but extensive intrahepatic topography was not seen (Fig. 4). Finally, in three patients extensive filling of the portal branches was seen, with illumination of the smallest radicals (Fig. 5). In four patients of the latter two categories, unligated collaterals filled, however, none have rebled at 10, 14, 15, and 17

months after operation. Their portal pressures as shunt cannulation were 13, 14, 26, and 28 cm saline. Portal flow was reversed in the remaining 18 patients (Fig. 6).

Postoperative Spontaneous PSE

Postoperative spontaneous PSE occurred in ten (37%) of the 27 surviving patients. PCHG-10/CL patients had PSE incidence of 31% (three severe, two mild), compared with 45% (four severe, one mild) in PCHG-12/14 patients (p = N.S.).

Of 18 patients with reversed flow, nine (50%) had postoperative PSE (three mild, six severe), compared with only one of nine (11%) with prograde portal flow (p = 0.05). The latter patient had severe PSE. To determine if risk factors predisposing to postoperative PSE biased these results, patients were assessed according to direction of portal flow, age, diabetes, Child's criteria, preoperative PSE, and emergency operation. Mean ages of patients with prograde and reversed flow were 49 ± 11 and 53 ± 7 years, respectively, (p = NS). Age did not influence the overall incidence of postoperative PSE (p = 0.19). Only five patients had diabetes, two with prograde, and three with reversed flow, and one of each group had postoperative PSE. The remaining data are summarized in Table 2. Emergency shunt did not influence the rate of postoperative PSE (p = 0.4), while the overall incidence of postoperative PSE tended to be higher in patients with more advanced liver disease (p = 0.06) and with preoperative PSE (p = 0.07). Generally, the relative distribution of patients according to the risk factors shown on Table 2 was similar for patients with prograde and reversed flow, but incidence of postoperative PSE was always higher in those with reversed flow.

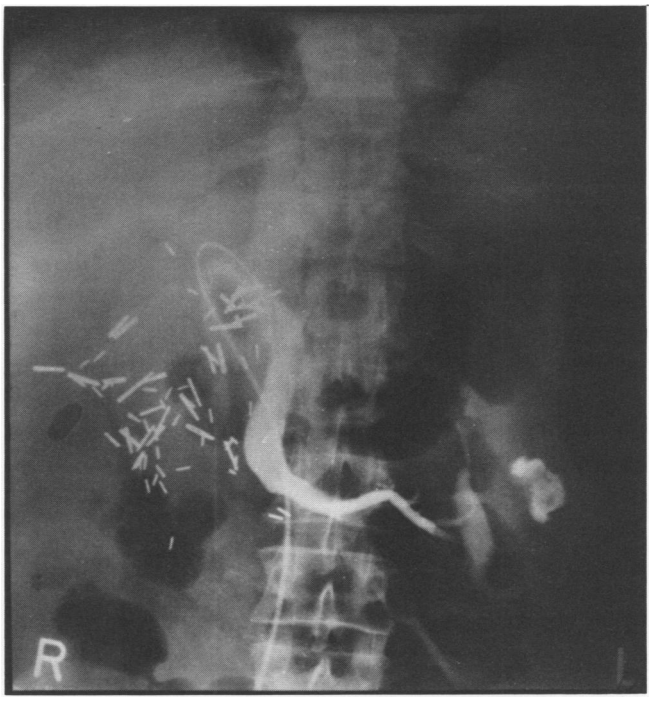

FIG. 6. All portal flow egress is via shunt, and intrahepatic flow is reversed.

Discussion

This study confirms the observations of Warren, Zeppa, and coinvestigators[1-3] that preserving prograde portal flow after portasystemic shunt minimizes postoperative PSE. Although this study was not randomized, all patients underwent a similar operative procedure (portacaval H-graft), the dependent variable being direction of portal flow. Postoperative PSE correlated with direction of portal flow such that this complication was always greater in patients with reversal of portal flow, regardless of Child's criteria, age, or emergency operation. The influence of preoperative PSE was assessed also, although quantitating this is difficult in actively bleeding patients. The effects of hypovolemia may hinder precise definition of encephalopathy. Nevertheless,

TABLE 2. *Distribution of Patients and Incidence of Postoperative PSE According to Preoperative Risk Factors and Postshunt Portal Flow Patterns*

	Prograde Flow			Reversed Flow			Total		
	No. Patients	No. with Postoperative PSE	Per cent	No. Patients	No. with Postoperative PSE	Per cent	No. Patients	No. with Postoperative PSE	Per cent
Total No. Patients	9	1	11	18	9	50	27	10	37
Operation:									
Emergency	4	0	0	10	6	60	14	6	43
Elective	5	1	20	8	3	38	13	4	31
Child's Category:									
A	4	0	0	7	2	29	11	2	18
B	4	1	25	9	5	56	13	6	46
C	1	0	0	2	2	100	3	2	67
Preoperative PSE	3	0	0	7	6	86	10	6	60

all patients who had episodes of stupor or coma before operation were included as having preoperative PSE. In these patients, when portal flow was reversed after operation, the overall incidence of PSE was 86%.

These results disagree with those of Bismuth.[4] In the latter study, portal flow patterns and shunt size did not correlate with rates of postoperative PSE. This study differs in several respects. The shunts were nonexpansile H-grafts, and hence, diameters were controlled. Postoperative angiography was performed using techniques that prevent misinterpretation of flow patterns such as "pseudoperfusion."[5] Finally, even using 10 mm H-grafts combined with portal collateral ligation, prograde portal flow was achieved in half of the patients. In these patients collateral ligation was performed in order to further direct portal flow toward the liver and shunt. This may maintain prograde protal flow in some patients since shunt gradients are increased by approximately 33% after collateral ligation. These results further suggest that prograde portal perfusion may be infrequent after standard mesocaval interposition H-graft, since typically 18–20-mm grafts are used.[7,8]

This study was performed because of the authors' extensive previous experience with various diameter portacaval Dacron interposition shunts.[9-11] In this position, graft patency is excellent compared with those placed in the superior mesenteric vein.[10] Portacaval H-grafts may be more successful because they are shorter, more direct, and are less likely to be compressed by adjacent structures. The experience of others[12] with PTFE in the portal venous system, encouraged the authors to try it. The initial results are somewhat disappointing since perioperative PTFE graft thrombosis rate approached 20% while none of the 12 or 14 mm Dacron grafts thrombosed. It was found that failure was due to kinking (the PTFE grafts used were neither crimped nor supported). While turbulence of flow because of higher shunt gradients cannot be ruled out as a cause, in seven patients studied after three months, no PTFE graft failures were found.

The authors are not advocating small-diameter portacaval H-grafts for managing patients with variceal hemorrhage. The incidence of postoperative PSE in the patients with reversal of portal flow is 50%, and postoperative flow patterns are not predictable. Furthermore, long-term patency of small-diameter portacaval grafts is unknown. Finally, it is not known whether prograde flow, when present in the immediate postoperative period, is maintained, since flow may reverse over time as after some distal splenorenal shunts.[13] These considerations are under study and will be reported subsequently. Nevertheless, shunt diameters as small as 10 mm, combined with collateral ligation, are successful in arresting or preventing variceal hemorrhage, despite persistence of some collaterals at angiography in a few patients. Ascites is not a postoperative problem, even in patients with significant prograde flow. The operations are relatively easy to perform since extensive caval and portal vein dissection and mobilization are unnecessary. The operative mortality of only seven %, despite more than half being performed as emergencies, and despite inclusion of patients with all stages of liver disease, attests to the safety of the operation.

In conclusion, 1) this study confirms that preserving prograde portal flow postoperatively is essential in minimizing PSE; 2) 10-mm PTFE shunts combined with collateral ligation perserve prograde portal flow in 50% of patients. Larger shunts consistently lead to reversed hepatic portal flow and loss of portal perfusion; 3) early failure rate appears to be due to technical factors; 4) long-term studies will define the role of small-diameter portacaval H-grafts for managing bleeding varices in patients who are not candidates for distal splenorenal shunt.[3]

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