
Portal Vein Injuries

Noninvasive Follow-up of Venorrhaphy

RAO R. IVATURY, M.D., F.A.C.S., MANOHAR NALLATHAMBI, M.D., F.A.C.S., DANIEL H. LANKIN, M.D.,
IRENE WAPNIR, M.D., MICHAEL ROHMAN, M.D., F.A.C.S., and WILLIAM M. STAHL, M.D., F.A.C.S.

The authors report their experience with 14 patients with portal vein injuries (1976–1986) treated at a level I trauma center. Seven patients (50%) survived and included six of 10 patients (60%) who had venorrhaphy and one in whom the portal vein was ligated. Associated injuries were present in all the patients (mean Abdominal Trauma Index: 39.5) and accounted for the high mortality rate. Follow-up data after repair or ligation of the portal vein seldom are reported in the literature. The authors studied all three patients who survived portal venorrhaphy since 1982 by real-time ultrasonography. Patency of the repair could be established in two patients. In the third patient postvenorrhaphy thrombosis was diagnosed by ultrasonographic examination. Sequential ultrasonographic examinations demonstrated resolution of the thrombus on anticoagulant therapy. Ultrasonography provides a noninvasive and easily reproducible method of studying the portal vein after repair.

TRAUMA to the portal vein is rare. In the last three decades fewer than 200 such injuries have been described in the literature.^{1–13} The largest series from a busy trauma center¹⁰ spanned a period of 23 years and included only 46 patients. These injuries often are lethal; the reported mortality rate resulting from uncontrolled hemorrhage varies from 50 to 70%. The frequent occurrence of concomitant injuries to other major organs and vascular structures, along with the technical difficulty of isolating and controlling the lacerated portal vein, contributes to this high mortality rate. Lateral venorrhaphy is the preferred method of management of the injured portal vein. More recently, however, it has been suggested that ligation of the vein is a viable alternative in patients with unstable conditions.^{7,8,10} Although there has been a significant survival

From the Department of Surgery, New York Medical College and Lincoln Medical Mental Health Center, Bronx, New York

rate after portal vein ligation, postvenorrhaphy thrombosis of the portal vein as a fatal complication has been reported by Fish² and Chisolm and Lenio.³ Portal vein thrombosis after repair may complicate postoperative fluid and electrolyte management as a result of splanchnic bed sequestration.^{12,14} Unfortunately, the real incidence of portal vein thrombosis after repair has not been investigated, probably because of the relative difficulty in investigating the portal system in critically injured and hemodynamically unstable patients.

In this report we present our experience with portal vein injuries, with particular emphasis on a noninvasive modality for the study of the repaired portal vein. To our knowledge, this is the first report of such a follow-up in a series of patients with portal vein trauma.

Clinical Materials and Methods

Between 1976 and 1986, 14 patients with portal vein injuries were treated at the Lincoln Medical and Mental Health Center, a level I trauma center. There were 12 men and two women, with an age range of 22–36 years. Seven patients were stabbed, and seven received gunshot wounds. All the patients had hypotension (systolic blood pressure less than 90 mmHg) on admission. Five patients had no palpable blood pressure. Two patients had emergency room thoracotomies for resuscitation, and in two others thoracotomies were performed in the operating room for aortic compression in an attempt to reduce intra-abdominal hemorrhage. None of these patients who were *in extremis* survived.

Associated injuries were noted in all of the 14 patients (Table 1), the liver being the most common organ injured. An associated bile duct injury was found in three

Presented at the Spring Meeting of the New York Surgical Society, April 8, 1987.

Reprint requests and correspondence: Rao R. Ivatury, M.D., Department of Surgery, Lincoln Hospital, 234 E. 149 St., Bronx, NY 10451.

Submitted for publication: June 11, 1987.

TABLE 1. Associated Injuries

Visceral Injuries		Vascular Injuries		
Location	No. of Patients	Location	No. of Patients	(No. of Survivors)
Liver	10	Hepatic artery	2	(1)
Pancreas	3	Superior mesenteric	3	(0)
Duodenum	3	Inferior vena cava	3	(2)
Spleen	1	Aorta	3	(1)
Biliary tract	4	Renal vessels	3	(2)

patients. One patient, with a severe crush injury of the duodenum and the head of the pancreas, required a pancreatoduodenectomy as well as portal and vena caval repair. Major vascular injuries were common (eight of 14 patients, 57%) and involved the hepatic artery (two patients) and the aorta, vena cava, and their tributaries (12 injuries in six patients). The mean abdominal trauma index of 39.6 testifies to the severity of trauma sustained. The patients received a mean of 10 units of packed erythrocytes (range: 6–26 units).

The portal vein injury was managed by ligation in one patient and venorrhaphy in 10 patients. Three patients died from exsanguination before repair could be attempted. Seven of the 14 patients (50%) survived, including the patient treated by portal vein ligation. Six of the 10 patients who had venorrhaphy survived. None of the four patients who required resuscitative thoracotomy survived. Five of the seven deaths occurred during operation, and two patients died in the intensive care unit. All the deaths resulted from a combination of uncontrolled bleeding and coagulopathy. The survivors

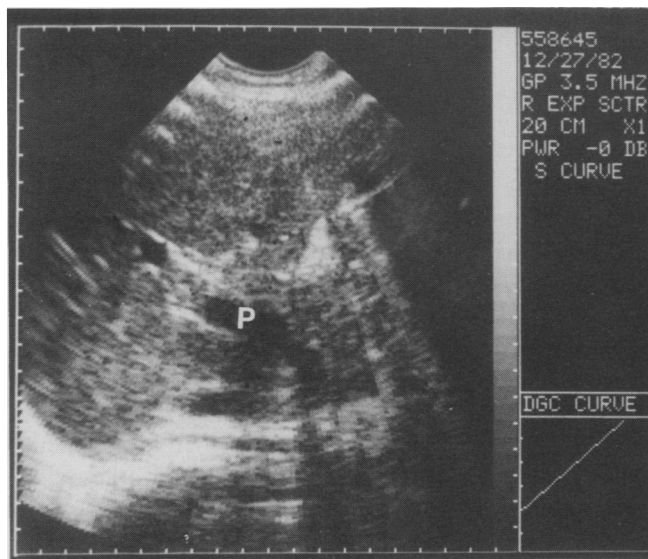


FIG. 1. Right oblique parasagittal view demonstrating thrombus (arrow) within the portal vein (P) with near-total occlusion of the lumen.



FIG. 2. Left oblique parasagittal view after 5 weeks of anticoagulation showing resolution of the thrombus.

had a mean Abdominal Trauma Index of 28.1, whereas the Index was 51 for those who did not survive. Four of the eight patients with concomitant major vascular injuries survived.

Follow-up of the Repaired Portal Vein

Since 1982, three of seven patients with portal vein injuries lived. In these patients, the portal vein was studied after operation by real-time ultrasonography. The first patient, who had sustained injuries to the portal vein and common hepatic duct that were treated by venorrhaphy and biliary ductal repair, had ultrasonographic examination of the abdomen on the 16th day after operation for a suspected intra-abdominal abscess. None was found. Instead, in the real-time study, blood could be seen swirling past an echogenic density that almost completely occluded the lumen of the portal vein (Fig. 1). Portal vein thrombosis was diagnosed. The patient was treated with continuous intravenous heparin therapy. In subsequent weeks, the patient improved clinically, and sequential ultrasonographic examination demonstrated resolution of the thrombus with complete restoration of the venous lumen of the vein by the 9th week (Figs. 2 and 3). He was discharged 3 weeks later. At the last follow-up visit, approximately 3½ years after injury, the portal vein was demonstrated to be normal on ultrasonographic examination. In the second patient, who had a pancreatoduodenectomy and portal vein and vena caval repair, ultrasonographic examination 2 and 5 weeks after the procedure proved the veins to be patent (Fig. 4). The third patient was a 17-year-old woman who had sustained injuries to the portal vein, abdominal aorta, and the renal vein. During an uneventful recovery



FIG. 3. Left oblique parasagittal view 3½ years later: portal vein (arrow) completely normal.

from the repair of these injuries, ultrasonographic examination on the 10th day after operation established patency of the repaired portal vein (Fig. 5).

Discussion

The experience with portal vein trauma of each of several busy trauma centers is limited to fewer than 50 patients collected over several decades. Stone et al.,¹⁰ for example, could find only 46 patients during a 23-year period. Despite this rarity, these lesions are of concern to the trauma surgeon because of their potentially lethal nature and the anatomic and physiologic importance of the portal vein.

The portal vein provides as much as 80% of the metabolic and oxygen needs of the liver and is the principal conduit for visceral efferent flow. The concealed location of the portal vein in the portal triad protects it from injury but presents numerous difficulties to adequate exposure and control. The frequent presence of concomitant injuries to other major vessels and organs contributes to massive blood loss. All of our patients presented with severe hypotension, and 57% of the patients had additional vascular injuries. Five (35%) were *in extremis* on admission, and each of four of them had a resuscitative thoracotomy and aortic occlusion before an attempt was made to control hemorrhage. As shown in this report and several others,³⁻¹² these factors contribute to a high mortality rate. Death occurred in 22 of the reported patients before the portal vein could be controlled.

The technical details of exposure of the portal vein and its tributaries are reviewed by Petersen et al.,⁷ Stone et al.,¹⁰ and, more recently, Sheldon et al.¹² and consist of mobilization of the right colon and small bowel mes-

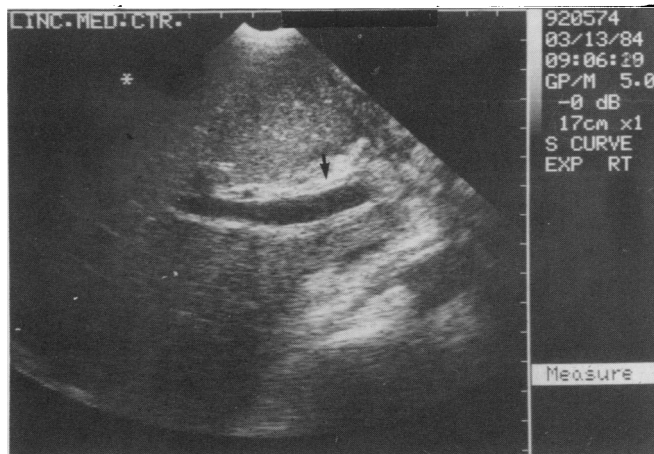


FIG. 4. Patient 2. Left oblique parasagittal view 5 weeks after repair, showing patent portal vein (arrow).

entry as well as the pancreas and the splenic vein to provide access to the posterior aspect of the portal vein. Occasionally, division of the pancreatic neck may be the only feasible approach to the retropancreatic confluence of the splenic and superior mesenteric veins.⁷ Packing, vascular clamps, and the Pringle maneuver are useful in temporarily staunching exsanguinating hemorrhage from the portal vein while other major vascular lesions are receiving attention.

Lateral venorrhaphy has been the preferred surgical approach and yields a significant survival rate (Table 2). In a few instances, an end-to-end anastomosis may be accomplished. For patients with injuries precluding portal vein reconstruction, portasystemic shunt has been proposed. However, the potential complication of hepatic encephalopathy and the inadvisability of per-

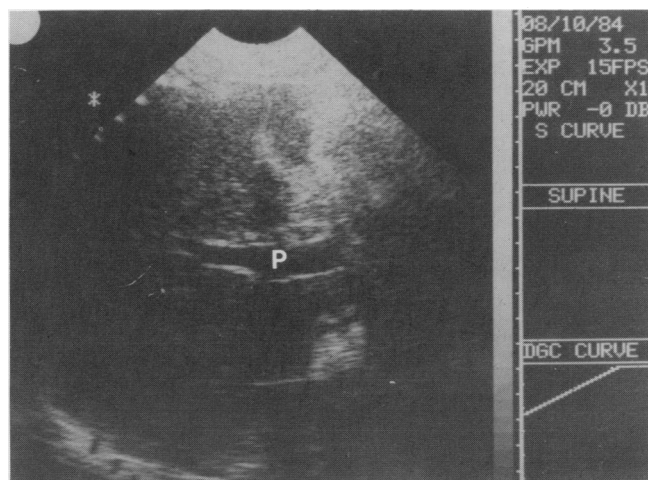


FIG. 5. Patient 3. Left oblique parasagittal view 10 days after repair, demonstrating patent portal vein (P).

TABLE 2. Management Methods in Reported Studies of Portal Vein Injuries*

Study	Repair	Ligation	Death before Repair	Other†	Total
Patton and Johnston, 1960 ¹	2 (2)	—	—	—	2 (2)
Fish, 1966 ²	2 (1)	—	—	—	2 (1)
Chisolm and Lenio 1972 ³	1 (1)	2 (1)	—	—	3 (2)
Bostwick and Stone 1976 ⁴ ‡					24 (6)
Mattox et al., 1975 ⁴ §					22 (11)
Graham et al., 1978 ⁶ §	26 (16)	4 (0)	5 (0)	2 (2)	37 (18)
Pachter et al., 1979 ⁸	—	1 (1)	—	—	1 (1)
Petersen et al., 1979 ⁷	19 (13)	5 (3)	3 (0)	1 (1)	28 (17)
Busuttill et al., 1980 ⁹	4 (3)	1 (0)	2 (0)	3 (2)	10 (5)
Stone et al., 1982 ¹⁰ ‡	17 (12)	18 (9)	7 (0)	4 (1)	46 (22)
Kashuk et al., 1982 ¹¹	8 (3)	1 (0)	—	—	9 (3)
Wienczek and Wilson, 1986 ¹³	12 (6)	3 (0)	2 (0)	—	17 (6)
Sheldon et al., 1985 ¹²					29 (?)
This study	10 (6)	1 (1)	3 (0)	—	14 (7)
Total	101 (62)	36 (15)	22 (0)	10 (6)	169 (84), 50%

* Number of survivors in parentheses.

† End-to-end anastomosis 5 (2); portasystemic shunt 2 (1); vein graft 3 (3).

‡ § || Some of the reports of patients in these studies were duplicated in subsequent reports from the same institution.

forming such a technically involved operation in a patient with an unstable condition argue against such a procedure. In his collective review of the literature in 1966, Fish² noted that encephalopathy developed in four of five patients treated by primary portacaval shunt. Other maneuvers, such as a saphenous vein interposition graft to the portal vein, have been employed sporadically (Table 2). Ligation of the traumatized portal vein is the other major option in management.

The Role of Ligation

After the initial observations of Child et al.¹⁵ that ligation of the portal vein was compatible with survival, this procedure found increasing favor. Pachter et al.⁸ reviewed 10 cases from the literature with five survivors and added another successful case of their own. In a more recent review, Stone et al.¹⁰ presented a survival

rate of 80% with planned ligation of the vein. A 2- to 36-month follow-up with angiography in five of the survivors of ligation showed excellent collateral flow to the liver and no evidence of portal hypertension. Similarly, a favorable survival rate was noted by Petersen et al.⁷ Even though one of their patients had an elevated portal pressure level after ligation of the vein, none had esophageal varices develop. It is recommended, however, that these patients be subjected to a "second-look" operation 24 hours later to detect small bowel infarction from portal hypertension.^{7,8,12}

The Fate of the Repaired Portal Vein

Although ligation is an acceptable option in the management of an unreconstructable portal vein laceration in the patient with an unstable condition, and although lateral venorrhaphy is the preferred mode of treatment, a relevant concern is the patency rate after repair. Unfortunately, this issue has not been addressed adequately in the surgical literature. Stone¹⁴ and Petersen et al.⁷ commented on the low patency of the portal vein after repair but did not provide specific data as to the number of patients studied *versus* the number of patent veins. In other large studies of portal vein trauma,^{4,6,12} follow-up studies of the repaired veins were not provided. As indicated in Table 3, data regarding the status of the portal venous circulation after repair are available in only 10 of the 169 patients described in the literature. Seven of these patients had ligation of the portal vein.

The complication of postvenorrhaphy thrombosis of the portal vein is not without significant sequelae. Patton and Johnston¹ recorded instances of portal hypertension with variceal bleeding secondary to portal vein thrombosis. Fish² and Chisolm and Lenio³ reported deaths resulting from this complication. Stone et al.^{10,14}

TABLE 3. Reported Follow-up after Portal Venorrhaphy or Ligation

Study	N	
Patton and Johnston, 1960 ¹	2	Portal vein thrombosis at laparotomy
Fish, 1966 ²	1	Portal vein thrombosis at laparotomy
Pachter et al., 1979 ⁸	1	Reconstitution of portal vein after ligation on angiographic examination
Stone et al., 1982 ¹⁰	5	Excellent collateral flow after ligation on angiographic examination
Ivatury et al., 1985 ²²	1	Portal vein thrombosis on ultrasonographic examination

and Pachter et al.⁸ emphasized the gravity of splanchnic pooling secondary to portal thrombosis. The resultant excessive sequestration of intravascular fluid may cause hypovolemia and hypotension. Precise hemodynamic monitoring becomes essential. It seems desirable, therefore, to study the portal vein after repair. However, the difficulty and the potential complications of performing invasive studies, such as selective angiographic examination, in a critically ill patient may outweigh the possible benefits from such studies. A noninvasive, easily reproducible investigation would circumvent these problems and may prove beneficial in the postoperative management. In our experience, ultrasonography has fulfilled these criteria. Further support for this approach may be obtained by examining the role of ultrasonography in nontraumatic conditions of the portal vein.

Ultrasonography in the Evaluation of the Portal System

The normal portal vein has been recognized as an important landmark in upper abdominal ultrasonography. Merritt¹⁶ studied the portal vein in 100 randomly selected examinations and identified it in 97% of the cases as it entered the porta hepatis, in 83% as it crossed the inferior vena cava, and in 83% at its origin. In addition, he documented the important ultrasonographic findings of portal vein thrombosis in three patients in whom angiographic examination subsequently confirmed this process. Raskin et al.¹⁷ diagnosed portal and hepatic vein thrombosis by ultrasonographic examination. Webb et al.¹⁸ documented the reliability of ultrasonography in assessing the patency of the portal vein in 20 patients with angiographic evidence of extrahepatic vein thrombosis. Employing real-time gray-scale ultrasonography, Weinreb et al.¹⁹ presented a standard chart of normal portal vein measurements in 148 patients. Furthermore, they successfully used "sonographic portography" to screen patients with cystic fibrosis for the onset and progress of portal hypertension. In a more recent communication, Van Gansbeke et al.²⁰ demonstrated the reliability of real-time ultrasonography in the detection of portal thrombosis. They also pointed out that the detection of multiple serpiginous periportal collaterals with inability to image the normal portal vein is important evidence of portal vein obstruction. These observations may find an application in the sequential study of the patient treated by portal vein ligation. Finally, the more sophisticated Duplex ultrasonography is capable of measuring quantitative flow of the normal portal system and the system with portasystemic shunts. Using this technique, Ackroyd et al.²¹ were able to measure portal flow in normal subjects and in patients with portasystemic shunts.

It is evident that ultrasonography provides a versatile, noninvasive, and reliable method for investigating the

portal system. Our data suggest that this modality may have an important application for the assessment of patency after portal vein reconstruction. In our first patient it facilitated an early diagnosis of portal vein thrombosis and enabled a serial follow-up while the patient was treated by anticoagulation therapy. In the other two patients, the portal vein could be identified and the patency of the repair could be documented. In patients treated by ligation of the portal vein, sequential ultrasonography may be of value in monitoring the development of collateral channels as well as portal hypertension, should it occur. Wider application of this noninvasive modality will, perhaps, enhance our understanding of the sequelae of venorrhaphy and ligation of the injured portal vein.

References

1. Patton TB, Johnston CG. Portal hypertension as the result of penetrating abdominal trauma. *Am J Surg* 1960; 99:651-656.
2. Fish JC. Reconstruction of the portal vein. Case reports and literature review. *Am Surg* 1966; 32:472-478.
3. Chisolm TP, Lenio PT. Traumatic injuries of the portal vein. *Am J Surg* 1972; 124:770-773.
4. Mattox KL, Espada R, Beall AC Jr. Traumatic injury to the portal vein. *Ann Surg* 1975; 181:519-522.
5. Bostwick J, Stone HH. Trauma to the portal venous system. *South Med J* 1976; 68:1369-1372.
6. Graham JM, Mattox KL, Beall AC Jr. Portal venous system injuries. *J Trauma* 1978; 18:419-422.
7. Petersen SR, Sheldon GF, Lim RC Jr. Management of portal vein injuries. *J Trauma* 1979; 19:616-620.
8. Pachter HL, Drager S, Godfrey N, et al. Traumatic injuries of the portal vein. The role of acute ligation. *Ann Surg* 1979; 189:383-385.
9. Busuttill RW, Kitahama A, Cerise E, et al. Management of blunt and penetrating injuries to the porta hepatis. *Ann Surg* 1980; 191:641-648.
10. Stone HH, Fabian TC, Turkleson ML. Wounds of the portal system. *World J Surg* 1982; 6:335-341.
11. Kashuk JL, Moore EE, Millikan S, et al. Major abdominal vascular trauma—a unified approach. *J Trauma* 1982; 22:672-679.
12. Sheldon GF, Lim RC, Yee ES, et al. Management of injuries to the porta hepatis. *Ann Surg* 1985; 202:539-545.
13. Weincek RG, Wilson RF. Abdominal venous injuries. *J Trauma* 1986; 26:771-778.
14. Stone HH. In discussion of Mattox KL, Espada R, Beall AC Jr. Traumatic injury to the portal vein. *Ann Surg* 1975; 181:522.
15. Child CG. *The Hepatic Circulation and Portal Hypertension*. Philadelphia: WB Saunders, 1954; 171-185.
16. Merritt CRB. Ultrasonographic demonstration of portal vein thrombosis. *Radiology* 1979; 133:425-427.
17. Raskin SP, Chiles JS, Hower JF, et al. Ultrasound findings in Budd-Chiari syndrome and portal vein thrombosis. *J La State Med Soc* 1981; 133:149-151.
18. Webb LJ, Berger LA, Sherlock S. Grey-scale ultrasonography of the portal vein. *Lancet* 1977; 2:675-677.
19. Weinreb J, Kumari S, Phillips G, et al. Portal vein measurements by real-time sonography. *AJR* 1982; 139:497-499.
20. Van Gansbeke D, Avni EF, Delcours C, et al. Sonographic features of portal vein thrombosis. *AJR* 1985; 144:749-752.
21. Ackroyd N, Gill R, Griffiths K, et al. Duplex scanning of the portal vein and portasystemic shunts. *Surgery* 1986; 99:591-597.
22. Ivatury RR, Rohman M, Lankin DH, et al. Ultrasonography in the diagnosis and management of postvenorrhaphy thrombosis of the portal vein. *J Trauma* 1985; 25:362-365.