Management of Injuries to the Porta Hepatis

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The management of injuries to the porta hepatis is challenging and controversial. Although definitive, anatomic reconstruction of injured ductal or vascular structures is optimal, porta hepatis injuries are universally accompanied by injuries to other organs (3.6 in this series), which often precludes initial repair. Moreover, frequent injury to the inferior vena cava, aorta, or other major blood vessels in addition to the structures of the porta hepatis results in these injuries being treated in conjunction with exsanguinating hemorrhage. For that reason, control of hemorrhage is the initial management priority, with the initial operation requiring expeditious, if less than anatomically exact, operations. Eighteen of 31 patients survived porta hepatis injury. Hepatic artery injuries were treated by ligation. Complex injuries to bile ducts frequently required enteric-ductal anastomoses as secondary procedures. Of 29 patients with portal vein injuries, six were treated by ligation, 22 by lateral repair, and one with splenic vein interposition graft. As in earlier reports, the structure of the porta hepatis associated with the highest morbidity and mortality rates when injured was the portal vein.

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INJURIES TO THE PORTA HEPATIS are among the most difficult management problems encountered in patients with abdominal trauma. Injury of the structures involved—the portal vein, hepatic bile ducts, and hepatic artery—has high potential for immediate or late mortality. Moreover, initial management, particularly of ductal and portal vein injuries, remains controversial. Although bile duct injuries may appear as occult injuries at time intervals remote from the injury, portal vein and hepatic artery injuries are usually identified during surgery in association with exsanguinating hemorrhage.[38]

Because of improved transportation, resuscitation, and prompt operation, injuries to the porta hepatis are now being encountered with greater frequency than previously. Nevertheless, porta hepatis injuries are relatively rare, with fewer than 10 manuscripts available in the literature, which is comprised of an experience of less than 200 cases.[3,8,10,17,18,23,24,28]

Clinical Material

The experience of the trauma service at San Francisco General Hospital was reviewed in conjunction with the world literature to evaluate the morbidity, mortality, and the management of porta hepatis injuries. Injuries to the gall bladder, constituting relatively simple injuries that are usually definitively treated by cholecystectomy, were excluded from the review, which encompassed the 15-year period of 1965 to 1981. Of interest, bile duct injuries were infrequently associated with injury to the portal vein, perhaps because of the high incidence of penetrating trauma (89%). The incidence of injuries to associated organs, however, was quite high, with a mean of 3.6 organs injuried, in addition to structures of the porta hepatis.

Major injuries to the porta hepatis occurred in 31 patients (Tables 1–4). All injuries occurred in conjunction with other major injuries. Seven patients had two structures of the porta hepatis injured; no patient had an injury to all three structures, that is, portal vein, hepatic artery, and bile duct.

One patient was treated 11 years after a complex biliary injury secondary to a gunshot wound for complications associated with a biliary stricture and cirrhosis with an intact portal vein and hepatic artery.

Twenty-four patients (94%) were admitted in severe shock with arterial blood pressure of less than 80 mmHg. Shock persisted after initial resuscitation in 23 patients, precluding preoperative diagnostic tests. Six patients had refractory shock necessitating emergency thoracotomy for resuscitation in the emergency room or operating room.

Injuries to structures in addition to the porta hepatis were common (3.6 per patient). Sixteen of the 31 patients sustained major vascular injuries in addition to injuries to the porta hepatis. The most common associated injuries were to the liver, pancreas, aorta, or inferior vena cava.

Twenty of the 31 patients survived porta hepatis injury. Uncontrolled hemorrhage resulted in eight deaths in the operating room. Three postoperative deaths occurred at 1, 5, and 11 days. A multiplicity of complications secondary to shock occurred in all surviving patients.

Management

The operative management of hepatic duct injuries was determined by the magnitude of shock and the location

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TABLE 1. *Porta Hepatis Injuries (31 Patients)*

Structure	Number
Portal vein	29
Common bile duct	3
Right or left hepatic duct	1
Hepatic artery	3

of the injury. In one patient with associated portal vein, inferior vena cava, stomach, duodenal, spleen, pancreas, bile duct, and hepatic injuries, a T-Tube was placed acutely because of the complexity and magnitude of the associated injuries, which necessitated portal vein ligation (Fig. 1). When the patient had recovered from a multiplicity of postoperative complications, a Roux-en-Y choledochojejunostomy was successfully performed 90 days after the injury (Fig. 2). A second patient with an injury at the bifurcation of the right and left hepatic ducts was treated emergently with U-Tubes placed in the right and left hepatic ducts after control of exsanguinating hemorrhage from the liver. Six months following injury, the high biliary tract disruption was treated by an intrahepatic hepaticojejunostomy. A third patient was treated for portal hypertension and bleeding esophageal varices 11 years after a gunshot wound to the distal common duct, which had been treated by choledochoduodenostomy. Because of cholangitis 9 years after injury, the patient was evaluated and found to have a biliary stricture. A Roux-en-Y hepaticojejunostomy was performed with good results. However, the patient had developed biliary cirrhosis, portal hypertension, and hematemesis. Because of hypersplenism and thrombocytopenia, the patient was treated with a distal splenorenal shunt. All surviving patients have done well for at least 1 year after operations.

Of four hepatic artery injuries, one was managed by direct repair and three by ligation. No patient developed any negative sequelae secondary to hepatic vein injury.

Portal vein injuries were successfully treated by lateral primary repair in 22 cases, portal vein ligation in six cases, and interposition splenic vein graft in one. All patients surviving portal vein injuries treated by ligation had "second look" operations because of the potential of intestinal infarction secondary to venous hypertension. Only one of six patients had elevated portal pressure measurement, and that patient currently has a caput medusae.

TABLE 2. *Mechanism of Injury and Mortality*

Type of Injury	Number of Patients	Mortality
Penetrating	28	
Gunshot wound	18	8 (25%)
Stab wound	10	3 (10%)
Blunt	3	
Total	31	11 (35%)

TABLE 3. *Porta Hepatis Trauma Associated Injuries*

Organ	Number
Major vascular	17
Liver	23
Pancreas	15
Duodenum	11
Stomach	9
Colon	5
Spleen	6
Small bowel	4
Kidney	3
Adrenal	3

Discussion

Penetrating trauma to the biliary tract is uncommon and frequently fatal because of a high incidence of injuries to the adjacent vascular structures. Blunt trauma to the biliary tree is rare, usually localized, and more amenable to operative management than penetrating injuries. Injury to the biliary tree secondary to blunt trauma is commonly undetected and may have delayed sequelae.

In 1972, Zollinger reported two cases of hepatic duct injury, involving the ductal system at or above the confluence of the right or left hepatic duct. Zollinger could find only 74 patients with ductal injuries in the literature since the 1880s, and the majority of reported cases involved only the common duct, not its right or left branch.[43]

Busuttil and Longmire in 1980 reported their experience with 21 patients with porta hepatis injuries accumulated from the experience of two institutions (University of California at Los Angeles and Charity Hospital, New Orleans) over 10 years. The mortality rate of 24% represented the best results of a large series of these uncommon injuries. As in all series, mortality was related primarily to the associated vascular injuries, not ductal injuries.[10]

Ivatury et al. reported a 10½ year experience of 51 patients with extrahepatic injuries.[21] In the literature, the authors could locate only four comparable series with a total of 85 patients. Their series revealed findings consistent with the literature—that 74% of the patients had injuries to the gallbladder. Complex injuries to the hepatic ducts, hepatic artery, or portal vein were uncommon.

TABLE 4. *Vascular Injuries Associated with Porta Hepatis Trauma*

Arterial	Number of Injuries	Venous	Number of Injuries
Aorta	6	Inferior vena cava	7
Splenic artery	3	Superior mesenteric vein	4
Superior mesenteric artery	2	Renal vein	4
Renal artery	1	Splenic vein	2
		Hepatic vein	1

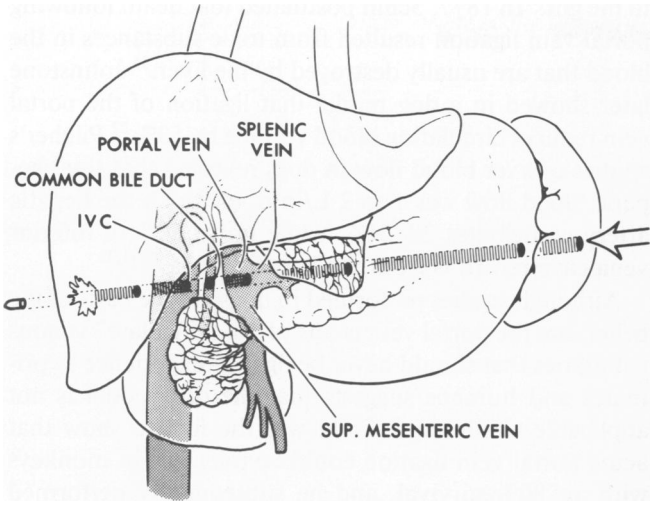

FIG. 1. Example of a gunshot wound in which the bullet entered the posterior left thorax, passed through the spleen, pancreas, stomach, splenic vein, suprarenal vena cava, portal vein, common bile duct, and liver. Initial control of caval hemorrhage, splenectomy, distal pancreatectomy, portal vein ligation, and suture of hepatic laceration were performed. A T-Tube was placed in the common bile duct. Secondary operations were required after recovery from multiple organ failure.

Most patients with porta hepatis injury are explored because of signs of intra-abdominal hemorrhage. Vascular injury associated with biliary tract trauma has a mortality of 50–75% for portal vein, 40–60% for vena cava, and 40–80% for hepatic artery. Moreover, all reported cases of porta hepatis injury have a universal high incidence of injuries to the liver, aorta, vena cava, and duodenum, which obviously contributes to morbidity and mortality. On the other hand, injuries to the intra- and extrahepatic ductal system are commonly insidious and associated with a delayed diagnosis.[17,32]

The best results for treatment of these complicated injuries occur when a treatment algorithm is followed (Fig. 3). The first priority is resuscitation by an experienced team. As most patients will be admitted with hemodynamic instability, the complex array of hepatico-biliary diagnostic tests is not applicable in the acute situation.

The first priority at operation is extensive anatomical delineation of the porta hepatis and paraduodenal area (Fig. 4). If the portal vein is injured by a missile that penetrates the pancreas, it is useful to divide the pancreas and repair entrance and exit wounds of the portal vein using the splenic vein to rotate the portal vein (Fig. 5). A Pringle maneuver is performed to control bleeding, while the vasculature and biliary tree is dissected. Associated vascular injuries, commonly of the vena cava or aorta, require control before the needed extensive dissection of the biliary tree. When control of injured vasculature is complete, the biliary tree is evaluated. Patients who have had a prolonged period of shock are best treated by T-

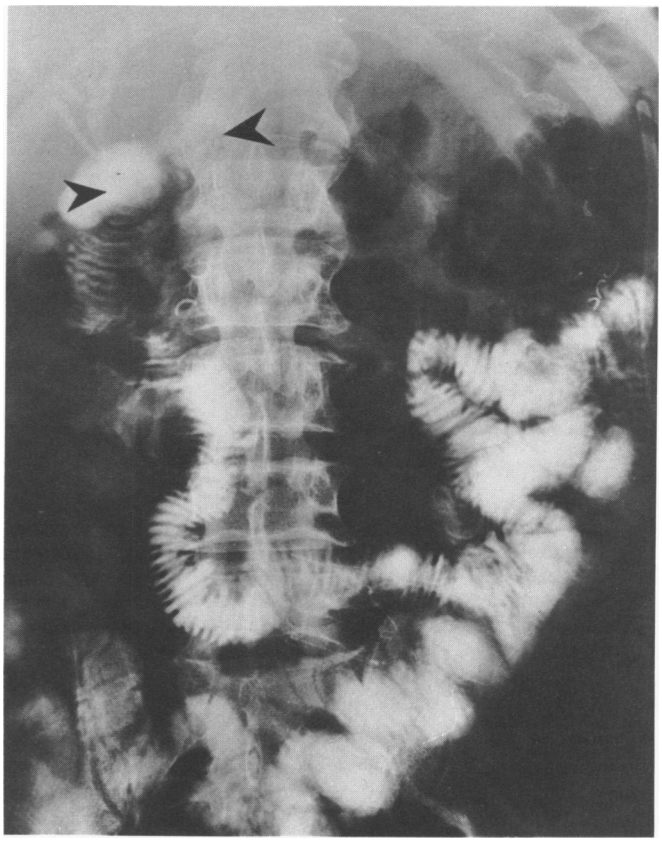

FIG. 2. Roux-en-Y choledochojejunostomy with a jejunal patch to a duodenal fistula (arrows). (Patient described in Figure 1.)

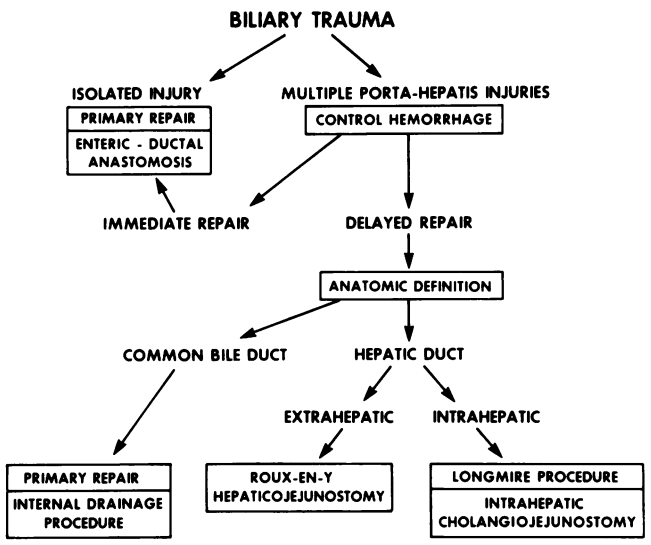

FIG. 3. Algorithm for treatment of porta hepatis injuries in which options for treatment of biliary injuries are outlined. If exsanguinating hemorrhage is present, delayed repair is recommended. If complex or delayed injuries are present, the spectrum of enteric-ductal anastomoses is recommended to avoid remote consequences of biliary cirrhosis, stricture, and cholangitis.

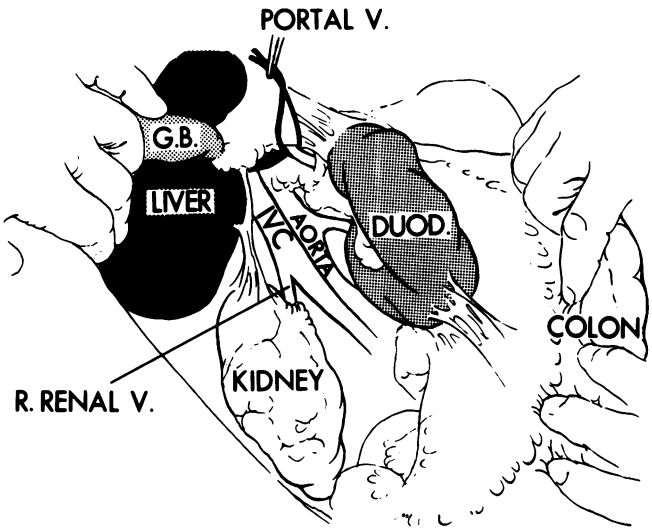

FIG. 4. Exposure of the porta hepatis is accomplished by a generous Kocher maneuver. For optimal exposure of the portal triad and other potentially injured structures, the colon is reflected medially to expose the duodenum and pancreatic head. Dissection in the porta hepatis allows isolation of the portal vein, biliary tract, and hepatic artery.

Tube drainage and staged repair. Stable patients or ones with secondary operations usually require an enteric-ductal anastomosis if a complex, extensive injury to the common bile duct or its tributaries is present.

Vascular Injuries

The most expedient solution to hepatic artery injury is ligation. Burton-Opitz found in 1900 that the liver could survive on portal blood flow alone.[9] Tygstrup subsequently found that the hepatic artery provides 30% of hepatic blood flow, but 50% of nutrient oxygen delivery.[41] Although isolated instances of hepatic necrosis have occurred after hepatic artery ligation, its occurrence is unusual.[27] If the hepatic artery injury involves the common hepatic artery or one of its branches and repair is difficult, ligation should be performed. The problem is more complicated in patients with underlying liver disease, such as cirrhosis, where ischemia may not be tolerated. Moreover, if the portal vein is injured in conjunction with the hepatic artery, the artery or vein, if not both, should be repaired. Fortunately, simultaneous injury of the portal vein and hepatic artery is less common than might be anticipated by their anatomical proximity, occurring in only four of 31 patients in this series.

Portal vein injuries have a reported mortality rate of 54–71% and represent the structure of the porta hepatis associated with the highest mortality. In 1856, Ore observed that ligation of the portal vein resulted in the death of three dogs.[30] Claude Bernard subsequently (1859) postulated that death following portal vein obliteration was due to exsanguination of blood from the brain and heart to the gut.[1] In 1877, Schiff postulated that death following portal vein ligation resulted from toxic substances in the blood that are usually destroyed by the liver.[35] Johnstone later showed in a dog model that ligation of the portal vein reduces circulating blood volume by 59%.[22] Pilcher's studies of liver blood flow in dogs revealed that total hepatic blood flow was 1 to 2 L/min, of which the hepatic artery contributes 20–25%, while up to 50% of inferior vena cava return is from the hepatic veins.[29,31,33]

Although studies performed in dogs are the basis of the belief that the portal vein is one of the "inviolate" venous tributaries that should never be ligated, experience in primates and humans suggests that the dog model is not applicable to humans. Child was the first to show that acute portal vein ligation could be tolerated in monkeys with an 80% survival, and he subsequently performed portal vein ligation in six patients during pancreaticoduodenectomy.[14] Isolated reports by Stone (8 of 10 patients survived), Petersen (3 of 5 survived), Hobson (Vietnam Vascular Registry—30 injuries), and Pachter (1) reveal long-term survival after portal vein ligation and survival without serious sequelae.[32]

Three patients in this series had "second look" operations because of the potential for small intestinal infarction from venous hypertension after portal vein ligation. Although no patients are known to have had that complication, one patient in this series had portal pressure measurements that were twice normal values. That patient has subsequently developed evidence of venous collateral circulation (caput medusae) secondary to portal hypertension, but without esophageal varices. All other patients

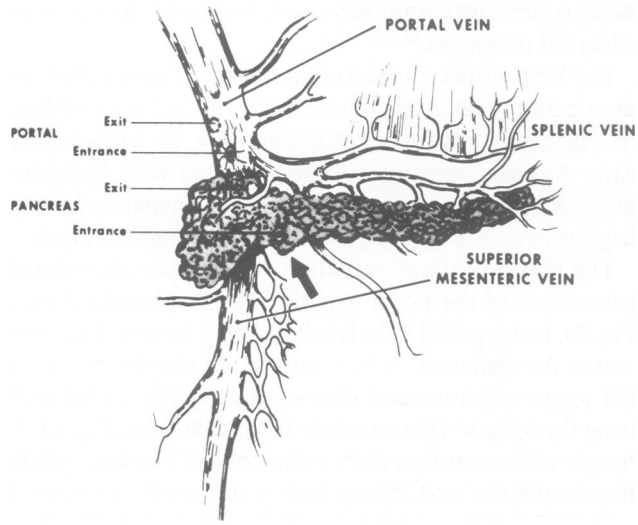

FIG. 5. Alternative exposure of the portal vein in patients with penetrating injury in which the missile passes through the pancreas and portal vein can be obtained by division of the pancreas. The splenic vein can be employed as a guide to rotate the portal vein and repair entrance and exit wounds of the portal vein. If this approach is used, a distal pancreatectomy is usually required.

had normal portal vein pressures, which is perhaps not surprising since only 14% of portal veins are devoid of collateral circulation.[14]

If possible, the portal vein should be repaired. If repair is not possible because of hemodynamic instability or extent of injury, ligation is the preferred second alternative. It is unnecessary and inadvisable to perform a porta-systemic shunt immediately following portal vein ligation in an unstable patient. Although our current experience suggests that patients tolerate portal vein ligation well, it is possible that some may eventually require porta-systemic shunting as a second procedure because of portal hypertension and its sequelae.

Hepatic Duct Injuries

Injuries to the hepatic ducts, if unrecognized, may result in a variety of nonspecific symptoms, including fever and jaundice. Large intra-abdominal collections of bile, if uninfected, are often well tolerated. Twenty-eight patients with missed ductal injury, representing the collected experience of the recent literature, have survived.[10,17,24,43] However, it is important to identify even a small injury in the ductal system, since inflammation, fibrosis, and eventual stricture will occur in undetected injuries.[10,19,23] If bile duct injury is suspected, the location of bile staining aids in identification of the location of the injury. As duodenal injury is commonly associated with hepatic duct injuries, it is often necessary to perform intraoperative cholangiography to identify the injury.

The extent of repair of the duct that is advisable in the acute situation depends on the patient's hemodynamic stability. If the patient is unstable, a T-Tube and drains are placed with the expectation of repairing the injury at a later date. If the bile duct is completely transected, an enteric ductal anastomosis is performed to the jejunum or the duodenum, because primary repair and T-Tube drainage of completely transected common bile duct predictably (over 90%) develop strictures.[4,5,24] Although no definitive evidence exists that a T-Tube stent is necessary, it is usually utilized.[7] Ductal injuries of less than 50% of the circumference of the duct can usually be treated by repair and T-Tube drainage[20] (Fig. 6). Ductal injuries that encompass more than 50% of the circumference of the duct are probably best treated by duct enteric anastomosis to avoid the complication of biliary stricture.[6,7,25] Complex injuries of the right or left hepatic ducts may require removal of liver substance to identify the right and left ductal system in order to perform a hepaticojejunostomy.[2,3,12]

Although delayed repair of biliary tract injury can be made difficult because of adhesions, staged repairs are superior to attempting complex surgery in patients with hemodynamic instability. The stent placed in the biliary tract during the initial operation, which provides access for cholangiograms, serves as a guide to the identification of the ductal opening during operation.[13,40]

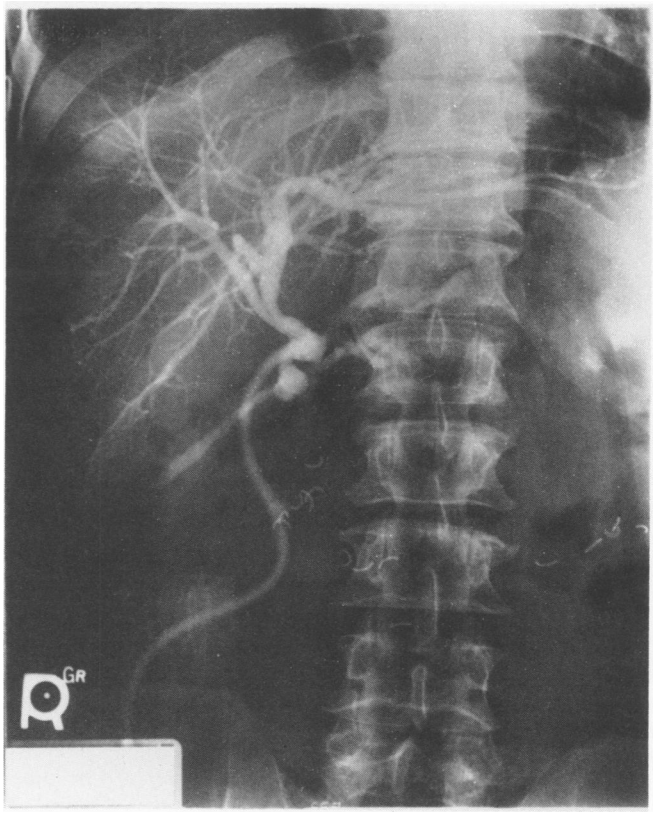

FIG. 6. Cholangiogram performed through catheter placed at initial operation. Although near-total transection of the common duct was identified, duct intubation was elected because of the complexity of the injury and hemodynamic instability. The catheter was left in place to aid in the reconstruction by duct-enteric anastomoses. (Patient described in Figure 1.)

Before reconstruction of the biliary tract is attempted, anatomical delineation is necessary, usually by transhepatic cholangiogram (THC). If biliary tract injury is present, drainage and diversion of bile can be accomplished by the transhepatic catheter.[16,28,37]

The choice of ductal-jejunal anastomosis is dictated by anatomical considerations. Choledochoduodenostomy is of use in the treatment of distal injuries only.[15,11] The most satisfactory method of reconstruction is hepaticojejunostomy and cholecystectomy.[39] Use of the gallbladder for biliary drainage, as is frequently done for cancer patients, is inadvisable, since the cystic artery is frequently inadequate if the hepatic artery has been damaged.[26]

The success of biliary tract reconstruction is dependent on a technically superior operation, with (1) meticulous dissection of all necrotic tissue and scar; (2) mucosa to mucosa approximation; and (3) reconstruction without tension. Direct mucosal grafts may be useful for reconstruction of proximal ductal injuries, although patency of that type of anastomosis has not been well established by follow-up studies of more than 2 years.

FIG. 7. Arteriogram performed prior to biliary tract reconstruction demonstrating patent right and left hepatic arteries and adequate liver blood supply. (Patient described in Figure 1.)

If biliary strictures occur, reoperations for recurrent strictures have a high morbidity. The success rate, however, of operations for biliary stricture is greater than 70% if they are performed before biliary cirrhosis is established.[36,38] The likelihood of a satisfactory result from operation for biliary stricture decreases after three attempts at correction of stricture or fistula.[24,42] An advantage of performing ductal-enteral anastomoses is that revisions of strictures are sometimes done by a "plasty" at the ductal-jejunal anastomosis, or by percutaneous dilation through a preplanned stoma of the defunctionalized limb.[34,36]

When reconstruction of the biliary tract is anticipated, detailed examinations of hepatic blood flow by selective arteriograms are performed also. The blood supply to the area of reconstruction must be satisfactory to ensure success of the procedure (Fig. 7). The venous phase of the angiogram allows delineation of the portal vein also (Fig. 8).

Conclusion

Complex porta hepatis injuries are most successfully managed by initial attention to vascular injuries with

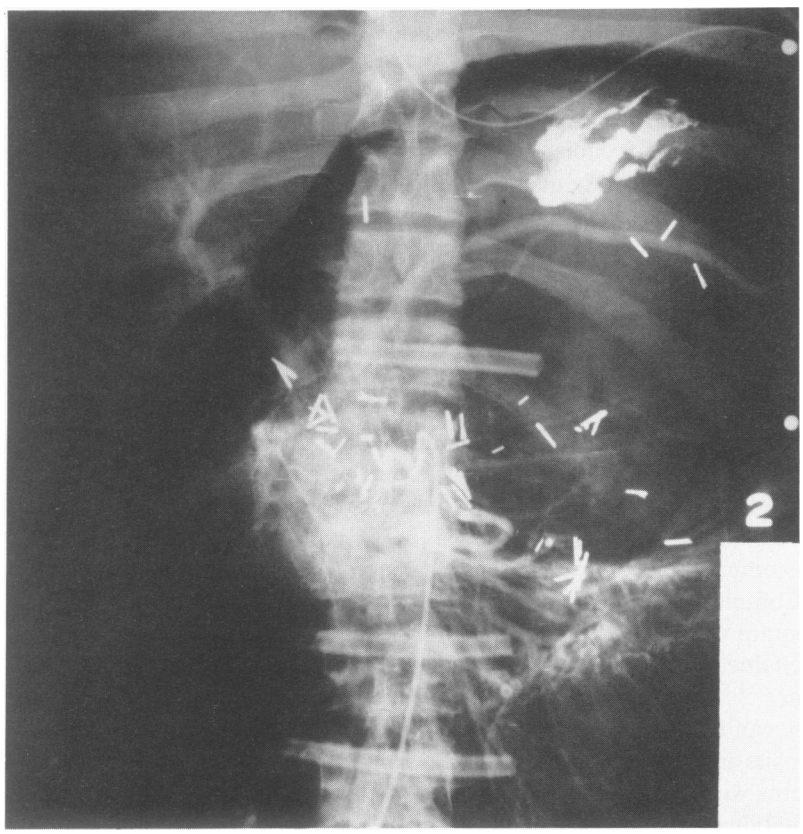

FIG. 8. Venous phase of coeliac arteriogram showing reconstitution of ligated portal vein. (Patient described in Figure 1.)

stenting of the biliary tract for delayed reconstruction in patients with hemodynamic instability. Injuries to the hepatic artery or its branches are usually managed by ligation. Portal vein injuries are the most common type of porta hepatis injury associated with mortality and are optimally treated by repair. Portal vein ligation is a reasonable alternative to repair if hemodynamic instability is present or if a technically impractical situation for reconstruction is present. It remains unclear if a secondary operation to perform porta-systemic decompression will be eventually required in patients with portal vein ligation.

The principle of secondary reconstruction is applicable to complex hepatic duct injuries as well as to portal vein ligation. Hepaticojejunostomy is the most satisfactory method of reconstruction to avoid late sequelae of biliary tract injury, such as stricture, cholangitis, and cirrhosis. Injury to the structures of the porta hepatis remains a challenging problem for surgeons who treat patients with trauma.

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