

Changing patterns of traumatic bile duct injuries: a review of forty years experience

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Received 2001-08-23 Accepted 2001-12-20

Abstract

AIM: To summarize the experiences of treating bile duct injuries in 40 years of clinical practice.

METHODS: Based on the experience of more than 40 years of clinical work, 122 cases including a series of 61 bile duct injuries of the Southwest Hospital, Chongqing, and 42 cases (1989-1997) and 19 cases (1998-2001) of the General Hospital of PLA, Beijing, were reviewed with special reference to the pattern of injury. A series of cases of the liver and the biliary tract injuries following interventional therapy for hepatic tumors, most often hemangioma of the liver, were collected. Chinese medical literature from 1995 to 1999 dealing with 2742 traumatic bile duct strictures were reviewed.

RESULTS: There was a changing pattern of the bile duct injury. Although most of the cases of bile duct injuries resulted from open cholecystectomy. Other types of trauma such as laparoscopic cholecystectomy (LC) and hepatic surgery were increased in recent years. Moreover, serious hepato-biliary injuries following HAE using sclerotic agents such as sodium morrhuate and absolute ethanol for the treatment of hepatic hemangiomas were encountered in recent years. Experiences in how to avoid bile duct injury and to treat traumatic biliary strictures were presented.

CONCLUSION: Traumatic bile duct stricture is one of the serious complications of hepato-biliary surgery, its prevalence seemed to be increased in recent years. The pattern of bile duct injury was also changed and has become more complicated. Interventional therapy with sclerosing agents may cause serious hepatobiliary complications and should be avoided.

Huang ZQ, Huang XQ. Changing patterns of traumatic bile duct injuries: a review of forty years experience. *World J Gastroenterol* 2002;8(1):5-12

INTRODUCTION

Since the first total cholecystectomy performed by Carl Langenbuch in 1882, there has been the likelihood of bile duct injury. But it was not mentioned until 1905 that Mayo reported the first two cases of bile duct stricture following cholecystectomy treated by choledochoduodenostomy^[1]. This might be due to the small number of operations performed by that time. However, the number of cases of bile duct injuries has been rapidly increased since then^[2]. In China, the prevalence of cholelithiasis is increasing, and cholecystectomy has become one of the most frequent operations in daily surgical

practice^[3-5]. The victims of bile duct injuries often suffered from great misery and the fatality rate can be as high as 30%^[6]. Efforts have been made in the training and standardization of conventional biliary operations such as cholecystectomy, the result being encouraging. Roslyn^[7] (1993) revealed 42,474 cases of open cholecystectomy from 1988 to 1989 (8% of cholecystectomies performed in America at the same period of time), and the bile duct injury rate has been lowered to 0.2%. In China, however, the bile duct injury during conventional open cholecystectomy has been claimed to be low, in spite of the lack of statistical data. In recent years, the number of reports on bile duct injuries due to cholecystectomies has been rapidly increased in the Chinese medical literature. The seriousness of the problem caused great concern from the medical professionals^[8]. Furthermore, the pattern of bile duct injuries at present also differed in some way from the traditional ones which imposed different methods of treatment. These may be complicated and unfamiliar to the practicing physicians and surgeons. In this report, we present our clinical experiences in the treatment of bile duct injuries over the past 40 years and specially the importance in laparoscopic, and bile duct injuries during liver resection and interventional therapy of hepatic lesions.

CLINICAL MATERIALS

Case records of traumatic bile duct injuries were reviewed. All patients in Group A and Group B series were the cases attended by the senior author either as the director or as senior surgeon of the department. Group A consisted of 61 cases of bile duct injury admitted to the South-west Hospital, Chongqing from 1963 to 1986;^[9] and Group B were 61 cases admitted to the General Hospital of PLA in Beijing from 1989 to 1997^[10] and from 1998 to 2001 (Tables 1,2).

Before 1990, the cases of traumatic bile duct stricture were mostly due to open celiotomy by conventional technique. Cases of bile duct stricture following laparoscopic cholecystectomy have been encountered since the turn of 1990 and cases of bile duct injuries resulting from the so-called 'mini-cholecystectomy' have been found in recent years. Up till now, bile duct injuries chiefly result from conventional surgery but not laparoscopic operations. Traumatic injuries and operations of the upper abdominal organs may cause bile duct injury, but biliary tract operations was the most common cause.

Table 1 Types of primary operations in 61 cases of traumatic biliary strictures (Group A, 1963/1986, South-West Hospital Series)

Types of operation	Cases
Cholecystectomy	39
Cholecystectomy + choledochostomy	10
Gastrectomy (B-II)	7
Hepatic injury -Rt lobectomy	1
Suture + gauze packing	2
Suture + choledochostomy	1
Suture + repair of duodenum	1
Total cases	61

**29 of the 61 cases were recognized by the operator during the primary operation

Table 2 Changing trend of primary operations in cases of traumatic biliary strictures (Group B: The General Hospital of PLA Series)

Types of operations	Cases	
	(1989-1997)	(1998-2001)
Cholecystectomy	27	8
Mini-cholecystectomy	2	
Laparoscopic cholecystectomy(LC)	4	5
Cholecystectomy + choledochostomy	9	
Hepatic resection	3	
Hepatic resection + HAE	1	
HAE		1
Gastrectomy(B-I)	1	
Total cases	42	19

In these 122 cases of traumatic bile duct injuries, cholecystectomy, especially simple cholecystectomies, was responsible for the majority of cases. As to the patterns of injuries, laparoscopic surgery, hepatic resection and interventional therapy for hepato-biliary diseases made a significant contribution in the Group B series.

Gastric resection The next common cause of extra-hepatic bile duct injury is gastric resection, which has been frequently employed for the treatment of chronic duodenal ulcer disease before the advent of the present anti-ulcer drugs. In series A, there were 2 cases of bile duct injury due to gastric resection probably through a not well-known mechanism which was differed from the ordinary direct operative injury. The first one was a male patient aged 42 years with a history of repeated hemorrhage from chronic duodenal ulcer for 7 years. On operation, a mass involving the posterior duodenal wall and the head of the pancreas was found and a Bancroft's type of gastric resection was performed. Four years following the operation, the patient still suffered from episodes of massive G-I bleeding accompanied with low blood pressure. Therefore, another operation was undertaken. The operation consisted of vagotomy and resection of the remanding portion of the gastric antrum together with the duodenal "ulcer" so as to control bleeding. However, the patient experienced a very stormy postoperative course. Jaundice appeared on the 4th postoperative day associated with daily chills and fever, while the gastric aspiration showed no bile. The patient's general condition was thus rapidly deteriorated. Re-operation was performed on the 6th postoperative day. A large amount of blood and bile tinged fluid was found inside the peritoneal cavity, and fatty necrosis was found around the head of the pancreas. A cholecystostomy was performed to relieve jaundice and drainage of the abdominal cavity. After the operation, a large amount of bile mixed with pancreatic juice (amylase activity was 1280 Winslow's unit) was drained outdaily through the cholecystostomy tube. Subsequently, further additional operations were performed for intra-abdominal residual abscesses. Eventually, the patient died of sepsis and wide spread intra-cranial hemorrhage. At autopsy, left-sided residual suphrenic abscess and empyema of left thorax was found, the ruptured duodenal stump was healed, and obstruction of the common bile duct at the ampulla below the confluence of the bile and pancreatic ducts was found so that pancreatic fluid was drained through the cholecystostomy tube by retrograde flow. There was no evidence of direct surgical injury or suturing of the lower end of the bile duct as the cause of biliary obstruction, however.

Another case was a middle-aged patient who also suffered from chronic duodenal ulcer complicated with repeated G-I hemorrhage. He was also treated at first by Bancroft's gastric resection and followed by resection of the gastric remnant and the ulcer because episodes of G-I hemorrhage recurred. The patient developed disruption of the duodenal stump and obstructive jaundice. PTC showed bile duct obstruction at the ampulla of Vater. This patient was firstly treated by abdominal drainage and cholecystostomy followed by Roux-en-Y

cholecho-jejunostomy and pancreatico-jejunostomy with an uneventful convalescence. This patient showed no excessive pancreatic drainage through the cholecystostomy tube because of the common bile and the pancreatic ducts were both obstructed at the ampullary level. In these two cases, the obstruction of the ampulla may be the result of operative interruption of blood supply to this particular region. However, the mechanism of such kind of bilio-pancreatic duct injury has not been well understood. **Interventional therapy and bile duct injury** In recent years, a particular type of bile duct injury was noted^[11], i.e., bile duct injuries following interventional treatment for hepatic tumors, most frequently for hepatic hemangiomas^[12] (Table 3). But such kind of bile duct injuries was usually not categorized under the heading of traumatic bile duct injury in hospital files.

Table 3 Hepato-biliary complications following HAE for cavernous hemangioma of liver

Case	Embolizing No. agents	Complications	Operations	Results
1	Sod.mo.+Lip.	Rt,Lt.CHD,GB Necrosis Biliary cirrhosis Liver abscess	S-R shunt B-jejunostomy	Jaundice ↓
2	Ethanol	Biliary fistula Liver abscess	Rt. Lobectomy B-jejunostomy	Jaundice ↓
3	Sod.mo.+Lip.	Rt-Lt-HD necrosis Liver abscess	PTBD Necrosectomy, U-tube	Jaundice ↓
4	Lip.wire Pinyanmycin	GB necrosis HD stricture Liver abscess	No	Jaundice ↑
5	Sod. Mo+Lip.	GB,CBD necrosis Liver abscess	Cholecystectomy T-tube stent	Jaundice ↓
6*	Sod. Mo+Lip.	Bile fistula Rt lobe atrophy Biliary cirrhosis	B-jejunostomy T-tube stent	Jaundice ↓
7*	Ethanol	Rt liver, GB, duodenum necrosis	Cholecystectomy Gastro-jejunostomy	Died
8	Sod.mo+Lip.	Rt liver abscess GB necrosis	Cholecystectomy Rt lobectomy Repair HD	Jaundice ↓
9*	Sod. Mo+Lip	Rt liver necrosis HD stricture Portal hypertension	No	Jaundice ↑ Repeated hematemesis

(Such type of bile duct injury was not included under the category of traumatic biliary injuries in the hospital records)

* Treated by consultation; Sod mo.=sodium morrhuate; Lip.=iodized oil; B=biliary; GB=gallbladder; CBD=common bile duct; HD=hepatic duct; S-R=spleno-renal;

PTBD=percutaneous transhepatic biliary drainage

Since interventional therapy was advocated for hepatocellular carcinoma in recent years with encouraging results, the method of percutaneous transarterial embolism (HAE) has also been advocated and used for the treatment of hepatic hemangioma^[13,14]. The embolizing agent used was usually sodium morrhuate which is a strong sclerosing agent commonly employed for injection of varicose vein of the lower extremities. But in hepatic hemangioma, after HAE with sodium morrhuate, the patient usually experienced a chronic course of progressive sclerosis of the intrahepatic and extrahepatic hepatic bile duct, persistent jaundice, progression of hepatic fibrosis and portal hypertension^[15].

A male patient aged 43 years, he was diagnosed having a hemangioma of the right liver after a routine physical examination with ultrasound scanning. He was advised to have a "catheter treatment" (HAE) for the tumor. According to the doctor's advice, he received a HAE treatment with injection of 10mL iodized oil and 4mL sodium morrhuate. He developed severe right upper abdominal pain, nausea and vomiting immediately after the injection. He was then admitted and treated in the hospital for one week, but he had constant upper abdominal discomfort after discharged from the hospital. Two years later, jaundice appeared which had been diagnosed as "viral hepatitis" and treated accordingly for 3 months. Exploratory celiotomy was

followed. A cholecystectomy was performed, exploring the common bile duct, in which a red-colored mucoid plug was found and removed. Three years later, a percutaneous transhepatic drainage of left intrahepatic bile duct was made because of persistent jaundice. A second operation of choledochal-jejunostomy was then performed. Despite of the operations, jaundice still persisted. He was at last admitted to the General Hospital of PLA in 1999, 6 years after interventional therapy for the liver hemangioma. Preoperative evaluation revealed fibrosis and atrophy of the right liver with the hemangioma still in situ, extensive fibrosis and stricture of the right hepatic duct involving the hepatic duct confluence and the left hepatic duct, and, hypertrophy of the left lateral segment of the liver with dilated intrahepatic bile ducts (Figures 1,2). A third operation was then performed. The left lateral intrahepatic bile duct was chosen for biliary-intestinal anastomosis. Because of the sclerotic changes of the hepatic duct confluence, a trans-round ligament approach for left hepatic duct-jejunostomy of Roux-en-Y type with stent was adopted. Jaundice decreased following the last operation. The other cases of HAE biliary injuries showed more or less similar clinical courses (Table 3). The clinical course and type of subsequent surgical treatment depended on the extensiveness of hepatic and biliary damages and the progression of hepatic fibrosis. Portal hypertension secondary to hepatic fibrosis may be developed and complicated with G-I hemorrhage. In all the cases under this category, the caudate lobe of the liver was found to be much enlarged and in a state of functional compensation.

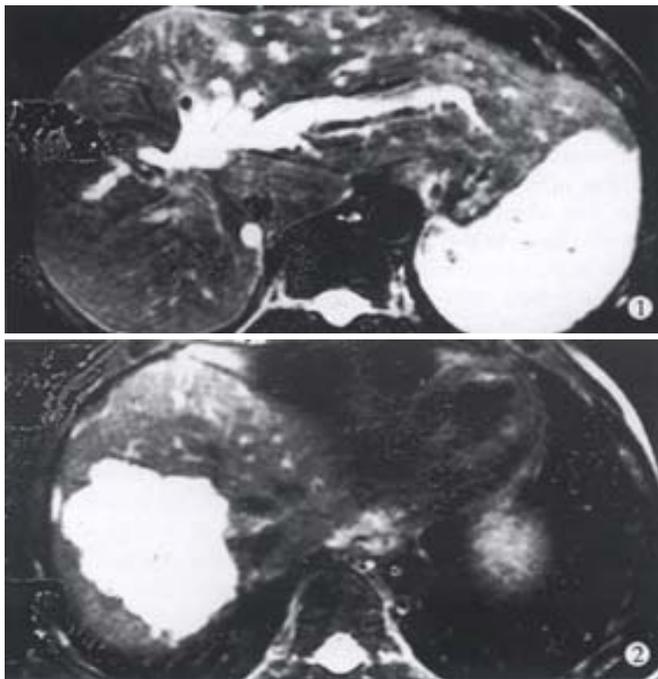


Figure 1 Hepatobiliary damages 6 years after HAE with sod. morrhuate: MRI showed atrophy of right liver, hypertrophy of the left lateral segment and obstruction of hepatic duct at the hila hepatis.

Figure 2 Hemangioma of right liver years after HAE. The same patient. MRI showed hemangioma still in place.

Hepatic trauma and bile duct injury Traumatic injury of the liver may be the cause of bile duct injury. Hepatic resections in daily surgical practice as one of the causes of bile duct injury is of increasing importance due to the rapid development of hepatic surgery in recent 20 years. In Group A series, we met a middle-aged male patient who sustained from severe laceration of the right lobe of the liver in a road accident. Resuscitation including emergency right hepatic lobectomy was undertaken in another hospital. However, injury to the left hepatic duct was inflicted and was recognized at

completion of the operation. Hence, repeated operations to treat the bile duct stricture and its complications were necessary subsequently, such as spleno-renal shunt for the treatment of portal hypertension and G-I bleeding, and attempts to recreate a patent biliary-intestinal passage. But operative attempts failed repeatedly because of marked enlargement of the left hepatic lobe and the extreme right posterior rotating displacement of the hilum which became inaccessible to the operation through the conventional surgical approach. The thirteenth operation was performed for the patient to complete a mucosa-to-mucosa anastomosis between the left hepatic duct and a Roux-en-Y jejunal loop through a low thoraco-abdominal incision. The patient recovered from the operation uneventfully and reported to have a satisfactory outcome. There was a young male patient in Group A. He had a severe crushing injury of the liver in a road accident. An external biliary fistula developed following incision and drainage treatment of a subphrenic abscess in right side after the primary operation, and 200-300ml bile was drained from the wound every day. Reoperation revealed traumatic rupture and occlusion of the right hepatic duct. He was treated, during the operation, using the gallbladder to form a conduit bridging between the right hepatic duct and the common bile duct. The biliary fistula healed after the operation.

Bile duct injury and hepatic resection In the past 10 years, more and more cases of bile duct injury due to elective liver tumor resections were admitted to the General Hospital of PLA for further treatment. In the Group B series, 1 case of bile duct injuries as a result of hepatic resection was recorded from 1989-1997. From 1998-2001, 3 additional cases were admitted to the General Hospital of PLA. According to our knowledge, besides the above mentioned cases, more than 6 cases were actually caused by hepatic tumor excision in our hospital. Five of these 6 cases had injuries to the left hepatic duct during the resection of tumors involving the left medial segment of the liver (Figure 3). The history of a case of left hepatic duct injury as a result of extended right hepatic resection for neurilemmoma and gauze packing to check bleeding was very illustrative to show the complexity of bile duct injury following hepatic surgery.

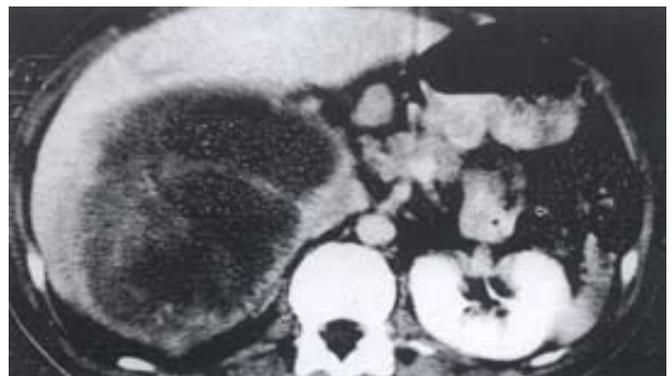


Figure 3 Neurilemmoma of the right liver: Resection of the tumor with right-sided tri-segmentectomy resulted into injury of the left hepatic duct.

A male patient aged 32 years was admitted to the General Hospital of PLA on 4 January, 2000. He had operative bile duct injury during resection of a neurilemmoma on 27 August, 1998. The tumor, weighting 5.0kg, situated in the right liver, was resected with difficulty and complicated with profuse bleeding. The estimated blood loss was about 27 000 mL. Gauze packing was used to stop the hemorrhage from the liver hilum upon completion of the operation. There was clinical jaundice on the second post-operative day. The gauze packing was removed on the 5th postoperative day through the celiotomy wound. On October 21, 1998, PTCD of the left intrahepatic bile duct was performed because of persistent jaundice.

As the indwelling catheter was withdrawn accidentally later on, another PTCB of the left intrahepatic duct was performed on December 23, 1999 when the serum bilirubin level was $543\mu\text{mol/L}$. The catheter was kept on draining of bile in the amount of $500\text{--}700\text{mL}\cdot\text{d}^{-1}$. Retrograde cholangiography showed complete obstruction of the left segmental bile duct (Figure 4). After admission to the General Hospital of PLA, the patient was reexamined and prepared for reoperation. During the operation, there was so dense fibrous adhesions and rich vascular communications in the hilar region that dissection of the extrahepatic bile duct was very difficult. Therefore, the left segmental bile duct was approached along the surface plane of the left external hepatic segment under the guidance of intraoperative ultrasound scanner. The site of the obstructed left intrahepatic duct was found posterior to the left portal vein. The operation was completed with a cholangio-jejunojejunostomy over a U-typed silicone rubber tube. This case illustrated the changing scope of traumatic bile duct strictures at the present that restorative treatment in many cases may be very complicated, and this might be the reason why this patient carried on his PTCB tube for as long as 2 years before referral to our hospital without further surgical intervention. The use of intraoperative BU-scan was important for the success of the operation in this case. Since bile duct injuries inflicted from hepatic surgery may have a very complicated clinical feature, therefore, for one or another reason, such patients may be withheld from appropriate and timely surgical intervention. This was reflected from what happened to a male patient at 40 years of age in Group B. He was diagnosed as having a cavernous hemangioma of quadrate lobe of the liver by ultrasound. The tumor was resected in another hospital. Following the operation, the patient developed obstructive jaundice, biliary peritonitis, and a big "biloma" in the upper abdomen. Re-exploration of the abdomen was carried out, bile-like fluid of about 2500mL was evacuated, however, the extrahepatic bile duct could not be found. The patient suffered from obstructive jaundice and subphrenic abscess without further treatment for 7 months. At last, when the patient was admitted to the General Hospital of PLA, his general condition was very poor and cachectic, the serum bilirubin level was $600\mu\text{mol/L}$. MRI examination showed a large subphrenic collection of fluid and markedly dilated intrahepatic bile ducts (Figure 5). Aspiration of the subphrenic abscesses showed infected bile collection. He was further treated by PTCB of the intrahepatic duct instead of reconstructive operation. In spite of the minimally invasive procedure, the patient developed hepatic coma and recovered only after a period of intensive medical treatment. He was waiting for further surgery when his condition was indicated for the operation. This was a typical case of negligence of medical profession. The difficult situations facing to the surgeon are the lack of knowledge and experience in handling bile duct injury following hepatic operations.



Figure 4 The same case as Fig 3. Retrograde cholangiography of the intraphepatic duct through a PTBD catheter showing obstruction of left intrahepatic ducts and hypertrophy of the left hepatic segment.

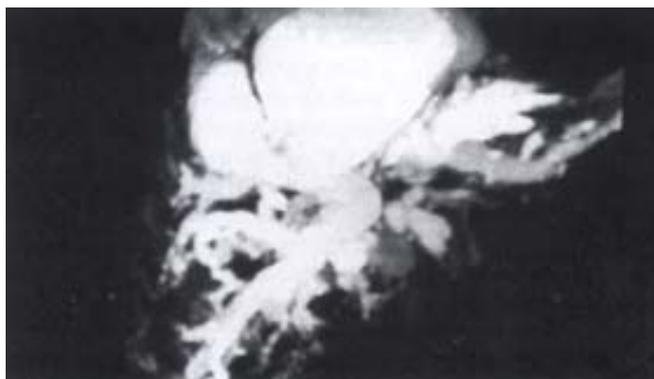


Figure 5 Bile duct injury in resection of quadrate lobe hemangioma: MRCP showing marked dilatation of the intrahepatic duct system with subphrenic collection of fluid. Extrahepatic bile duct not visualized.

DISCUSSION

Safety of cholecystectomy The current cholecystectomy should be a safe and effective operation. For example, in a review reported on the safety of laparoscopic cholecystectomy for cholelithiasis^[16], 4655 consecutive cases of cholecystectomies for gallstones one year before laparoscopic cholecystectomy (LC) was initiated were collected from 34 well equipped hospitals in China. Among these cases, postoperative complications which needed reoperative intervention occurred in 17 cases (0.36%), complications with lasting sequelae in 2 cases (0.05%), and death in 8 cases with a mortality rate of 0.18%. Most of the deaths were related to emergency operation in high risk patients^[16]. More or less similar result was obtained by Roslyn^[7] who revealed 42,474 open cholecystectomies performed in the year 1989 in America with a mortality rate of 0.17%. Injury to the bile duct is still a serious complication during cholecystectomy. Presently, incidence of bile duct injuries in open cholecystectomy has been decreased to a rather low level. Clavien *et al*^[17] reviewed the result of open cholecystectomy in the hospitals in North America and in Europe, injuries to the extrahepatic bile duct was found in 0.2% of the 1, 252 operations. But, bile duct injuries occurred more frequently in laparoscopic cholecystectomy than in conventional open cholecystectomy^[18-21]. The latest data about laparoscopic cholecystectomy collected by Huang *et al* showed that bile duct injuries occurred in 0.30% and biliary complications (including postoperative bile fistula which might be the result of minor bile duct injuries) occurred in 0.60% of the cases in China^[22]. The reported incidence of operative injury of the bile duct may be much lower than actually existed, however. This is true in China and as well as in the other parts of the world. Therefore, the reported incidence of traumatic bile duct injury in laparoscopic cholecystectomy was around 0.15% (9/5680)^[23] from a single hospital to 0.19% in a review series, but the result of about 0.5% in some western countries^[24,25]. A review of recent Chinese medical literature (1995.1-1999.12) on trauma to the extra-hepatic bile duct^[26] revealed that the spectrum of bile duct injuries occurring most frequently was the operations related to cholecystectomy, which accounted for 94% in 2,566 cases (Table 4).

Table 4 Bile duct injury and the type of operations in 2742 cases (Chinese literature review 1995-1999)

Type of operation	No. of cases	%
Cholecystectomy	1 933	70
Laparoscopic cholecystectomy	310	11
Cholecystectomy + choledochostomy	165	6
Gastrectomy	66	2
HAE*	16	0.6
Hepatic resection	10	0.4
Other operations	66	2
Unspecified	176	6

*HAE = Hepatic arterial embolization

There were cases of bile duct injuries from HAE and hepatic resections (0.6% and 0.4% respectively), and bile duct injuries due to laparoscopic cholecystectomy accounting for 11% of the total series. This variations in the disease pattern of benign biliary stricture were in accordance with the current changing practice of hepato-biliary surgery.

Surgical treatment of traumatic biliary stricture Since bile duct injury cannot be eradicated by biliary surgery as human beings are not exempt from errors. Therefore, prevention as well as treatment of bile duct injuries is still most important in biliary surgery [27-29]. In our experience, the long-term good results of reparative operation of traumatic bile duct stricture may be as high as 90% and 95%^[9,10]. In average, especially when reconstructive surgery was performed in those hospitals lack of expertise in biliary surgery, the result may be far from satisfactory, the postoperative morbidity rate and reoperation rate was high, and the mortality rate may be as high as 30%. Many of the patients carried on a miserable life (so-called biliary cripple) and eventually died of hepatic failure. Option of methods of surgical treatment for traumatic biliary strictures is varied according to different authors. In our experience, the best result was obtained after bilio-enterostomy of Roux-en-Y type with application of plastic reconstructions of hilar bile duct remnant. Therefore, in the two series of cases in this report, satisfactory result was obtained in more than 90% of the treated cases. In our series, all of the patients were referred from elsewhere in our country, and most of them have had multiple unsuccessful operations and came to our hospital as the last resort. One patient with traumatic bile duct injury had been operated upon as many as 12 times. Secondary surgical repair of biliary stricture is more difficult than the primary reparation because of the much distorted local anatomy and, in many of the cases, the level of bile duct stricture may be extended above the hepatic confluence to involving both hepatic ducts (Bismuth classification type IV), which is the most difficult situation to be treated.

In the treatment of traumatic bile duct stricture, the type of surgery seems to have important influence on the outcome of the disease. We preferred cholangio-jejunostomy of the Roux-en-Y type for reconstruction, especially for those late cases and those high strictures in which one or both hepatic ducts may be involved. Therefore, we used such type of operative repair in 47 of the 61 cases (77%) of Group A. Besides, in 4 cases with a functioning distal common bile duct, we adopted the principle of preservation of the sphincter of Oddi's function by using a pedicled gastric or jejunal patch for the repair. With an interposed jejunal loop with artificial nipple formation, hepatico-duodenostomy was employed in 2 cases. By such methods of management, we obtained good long-term result of 95.6% (including 2 reoperations 2 and 30 years after the first repair respectively). Two patients (4.4%) in Group A died of suppurative cholangitis 4 and 12 years respectively after the repair. Based on our experience in bile duct surgery, we have set up some guidelines for the surgery of biliary stricture which were proved to be important in clinical practice. They are: ① Strategy of traumatic biliary stricture repair: primary repair is critical, but early repair is more frequent, thus being, more important; though reoperations are difficult, they should be performed with confidence; operation should be staged in the presence of marked portal hypertension; operations should be a wait ted till marked biliary cirrhosis with liver dysfunction; ②. Technical essentials in reparative operation: side-to-side bilio-enterostomy is the first choice to minimize late stricture formation; single-layered anastomosis is essential; absorbable or single strand suturing materials should be provided; stent placement of 9 months or 1 year, if possible; good quality stenting tube should be selected to prevent accidental breakage; It should be kept in mind that there were '3 hepatic ducts' at the hilum of liver instead of only 2 as generally believed; ③ Alternatives: T-tube, Y-tube, and U-tube all

have merits for stenting; straight-tube, and shape-memory tube may be used at special occasions; Trans-hepatic tube may also be used for prolonged stenting and instrumentation; Finally, bile duct surgery is more or less alike to cannal engineering.

LC bile duct stricture Treatment of traumatic injury of extrahepatic bile duct due to laparoscopic cholecystectomy is a special problem of current biliary surgery. Though the number of laparoscopic injuries was relatively low in comparison with the open technique, for example, 310 of 2742 cases of bile duct injuries (12%) in a literature survey^[26] and 4 of 42 cases (9.5%) of bile duct injuries in the General Hospital of PLA from 1989-1997^[10]. In a review of 182 cases of bile duct injuries from 4 medical centers (1999), 30 cases(17%) were due to LC^[30]. Reports of LC bile duct injury have appeared since 1991 when the technique of laparoscopic cholecystectomy was first introduced to China mainland, but the number of patients rapidly increased as time went on. Therefore, LC bile duct injuries were found in 5 of the 19 cases treated in the General Hospital of PLA between the years 1998 and 2000, accounting for 26.3%. With accumulated experience of treatment of LC bile duct injuries, certain characteristic features were apparent. Most of the severe bile duct injuries of LC belonged to the so-called "classical injury" classified by Davidoff^[31]. Usually there was loss of a segment of the upper bile duct and involvement of one or both hepatic ducts. Sometimes, one of the injured hepatic ducts in the hepatic hilum may be hidden from the operator's sight (the right posterior duct being the most often and also occasionally the left hepatic duct) (Figures 6,7). Retained foreign materials (usually a broken piece of plastic tube which was used for internal stenting) were found more often. Spontaneous biliary duodenal fistula may be found in cases with no clinical jaundice. On the other hand, in many cases, when secondary repair was undertaken, the degree of intra-abdominal inflammatory changes and extent of adhesions were less than in the operation after conventional open surgery, therefore, a repair operation for the injury or anastomosis with the gut can be considered. These characteristic features of LC bile duct injuries demanded a change of surgical policy in the management of bile duct injuries for a better result^[32-34].

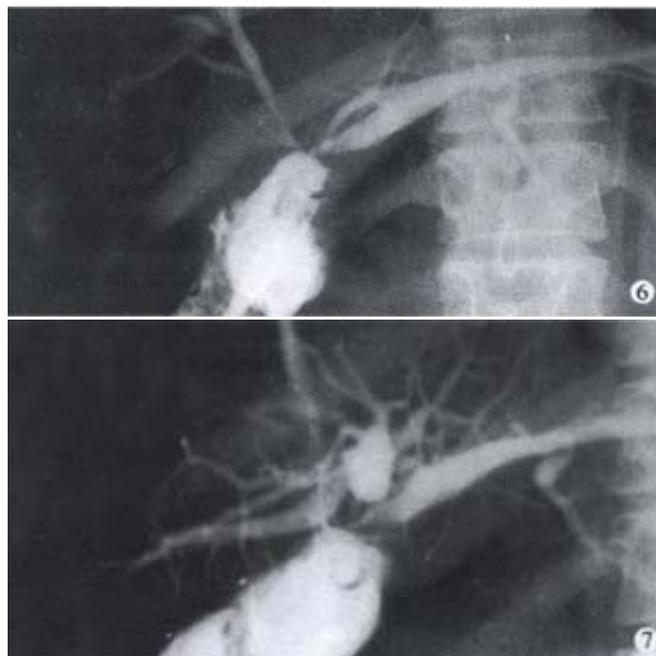


Figure 6 LC bile duct injury: Bile duct repair by hepatico-jejunostomy of Roux-en-Y tye. Postoperative retrograde cholangiography only the right anterior segmental duct and the left hepatic duct visualized.

Figure 7 The same case. PTC showing the dilated blind end of the right posterior segmental duct which was "missed" during the operation.

Gastric resection and bile duct injury Gastric resection is the next most common cause of operative bile duct injury. In a review of 2742 cases of bile duct injuries reported in Chinese literature by Huang *et al*^[35], 66 cases occurred during gastric resection operation, accounting for 2.4% of the total. The most severe type of such kind injury was trans-section of the common bile duct together with the hepatic artery and the portal vein. Such type of injury gave a high fatality rate (11/11). Among the patients in series A, two incidences showed a similar clinical manifestations following gastric operation for bleeding chronic penetrating duodenal ulcer. The mechanism of such type of damages may be related to the disruption of blood supply to the duodeno-ampullary region. Disturbance of local blood supply resulted in the coexistence of disruption of the duodenal stump and fibrotic obstruction at the ampulla. Blood supply of the extrahepatic bile duct is segmental. The supra-duodenal portion of the common bile duct received arterial blood supply chiefly from branches sent by the hepatic artery proper, while the lower portion of the common bile duct including the ampullary region received blood supply chiefly from the posterior pancreatico-duodenal artery that was derived from the gastroduodenal artery^[36,37]. Operation of excising the bleeding duodenal ulcer would inevitably result in the disruption of local blood supply and lead to the dishesion of the duodenal stump and fibrotic occlusion change of the ampulla.

Interventional therapy and bile duct injury Since bile duct injuries and its consequences are the ever existing problem of hepato-biliary surgery including interventional therapies of many hepato-biliary affections^[38,39]. A kind of severe extensive damage of the intraand extra-hepatic bile duct as a result of inadvertent use of sclerosing agents in the treatment of liver tumors (most often hemangioma of the liver) was noted^[11,13,14,40]. Six cases were admitted to our hospital on account of complications such as liver necrosis and abscesses, biliary intestinal fistula, extensive hepatic fibrosis complicated with portal hypertension, G-I bleeding, extensive destruction of the intra- and hilar bile duct with obstructive jaundice, etc. The sclerosing agents that most commonly employed were sodium morrhuate and absolute ethanol^[13,14,41]. Furthermore, we have also attended 3 cases through consultation. One case of asymptomatic haemangioma of the right liver was treated in another hospital by injecting 19ml absolute alcohol through the hepatic arterial catheter. The patient suffered from severe abdominal pain soon after the injection and was operated upon because of signs of acute peritonitis on the third day after the procedure. During operation, necrosis of the right liver, the biliary tract and the duodenum was found. The patient developed biliary fistula, and eventually died of multiple organs failure on the 10th day after the therapy. The other 2 patients suffered from repeated G-I bleeding because of portal hypertension due to hepatic fibrosis. Trans-hepatic arterial embolization (HAE) is a kind of interventional therapy which was widely employed as the current non-surgical treatment for advanced hepatocellular carcinoma(HCC)^[42-47]. In general, the embolizing agents consisted of lipoidal oil and small particles of gellform sponge. Particles of 1-2 mm in size would block the small intrahepatic arteriols about 50 μ m in diameter, and caused necrosis of the tumor mass. The gellform sponge particles will be dissolved in a course of about 2 weeks. While, on the other hand, if liquid materials are used as embolizing agent, such as absolute ethanol and sodium morrhuate, the drug may reach the end of the hepatic arterioles, causing damages to the liver parenchyma wherever the drug reached. Therefore, liquid embolizing agents will cause more extensive liver necrosis and damages to the intrahepatic bile duct by way of the peribiliary plexus. The resulting complications will be necrosis of the gallbladder, destruction of the intrahepatic bile duct system, liver abscesses formation, sclerosis of intra- and extra-hepatic duct, necrosis of the gall bladder with biliary duodenal fistula formation, and hepatic fibrosis (Figures 8, 9). If a more caustic agent (such as absolute ethanol) is used, immediate coagulation necrosis of the bile duct and liver parenchyma will occur. If the drug

was used in excessive amount or being injected too rapidly (as often the case when mechanical automatic injector is used), there will be retrograde flow of the drug causing extensive damage of extrahepatic intra-abdominal organs.

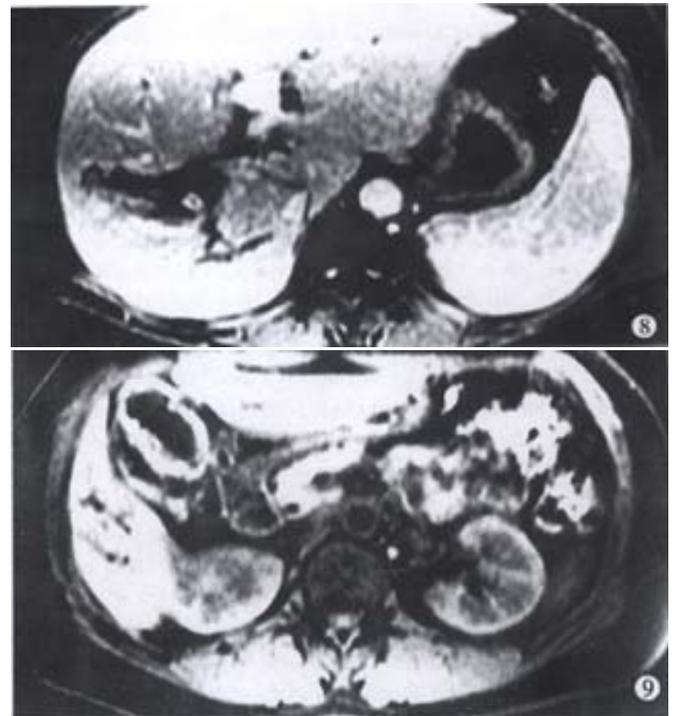


Figure 8 Fibrosis and obstruction of hepatic duct following HAE with injection of sodium morrhuate: 2 years after the procedure.

Figure 9 The same case. Necrosis of the gallbladder and the hepatic duct.

Liver receives double-sourced blood supply, arterial blood composed of 25%-30% of the hepatic blood inflow and supply 50% of the total oxygen expenditure of the liver. The hepatic artery, after entering into the liver parenchyma, sends branches to the hepatic duct, forming a complicated peribiliary plexus which by way of the portal vessels reaches hepatic sinusoids^[48]. The intrahepatic bile duct system, differing from the hepatic cells, received blood supply exclusively from hepatic artery. Blood supply of the common hepatic duct and the right and left hepatic duct is derived directly from the right and left hepatic artery, forming a peribiliary vascular plexus in direct connection with the intrahepatic peribiliary vascular plexus^[49]. Therefore, inadvertent intra-arterial injection of sclerosing agents into the hepatic artery will result in destruction of the intrahepatic bile duct, as well as sclerosis and obstruction of the right and left hepatic duct at the hilum hepatis. However, the common bile duct under such conditions was often found to be exempt except when retrograde flow of a large amount of the drug occurred. This is explained on the ground of vascular pattern of the common bile duct that the vascular plexus of the common bile duct is derived chiefly from the branches of gastroduodenal artery that connect with the vascular plexus of the intrahepatic bile duct indirectly. Furthermore, as we found in the reported cases of intrahepatic bile duct damage resulting from HAE that in spite of atrophy of the right and left hepatic lobes, the caudate lobe was usually markedly hypertrophied so as to take over the functional role of the liver. This phenomenon is also explained on the basis of blood supply of the caudate lobe. The caudate lobe of liver received bilateral hepatic arterial and portal venous blood supply, therefore, may be exempt from the injurious effect of HAE.

In recent years, HAE has been widely used as a therapeutic modality in the treatment of advanced HCC and was claimed to be safe and effective. However, serious biliary damage was found when

HAE was applied to treat cases of hepatic haemangiomas with sclerosing agents as shown in this report. There may be fundamentally different hemodynamic patterns between malignant and benign lesions of the liver. It was well known that arterial blood supply to HCC is much increased with dilatation and increased number of arterial branches to the tumor. Under such conditions, intra-arterial injection of sclerosing agents may be diverted from the accompanying intrahepatic bile ducts. While, in case of liver hemangioma, configuration of vascularity of the liver remained almost the same as found in the normal liver, therefore, more injected toxic agents will be directed to the intrahepatic biliary plexus and caused damages. A large volume of injected material (such as absolute ethanol) by high speed under pressure injection, and displacement of the intra-arterial catheter may render the situation worst as wide spread retrograde flow may occur as result of arterial spasm. Many cases of bile duct damage resulting from HAE employing sclerosing agents (generally not categorized under traumatic bile duct injury) may not be amendable to surgical treatment because of the extensiveness of the lesion. The authors have treated 11 such cases during the last 10 years (including 3 cases by consultation). Among these cases, 2 were not treated surgically because of extensive sclerotic cholangitis of the intrahepatic bile duct. One case of intrahepatic sclerosing cholangitis resulting from injection of absolute ethanol into a hydatid cyst of the right liver which happened to have a fistula communicating with the hepatic duct. One case of hemangioma of the liver died of multiple organs failure after the injection of absolute ethanol. The other 6 patients were treated by drainage of liver abscess, resection of damaged liver lobe, reconstruction of cholangio-enterostomy with an indwelling U-tube for stenting, and, in one case, a preliminary spleno-renal shunt was required before definite bile duct operation was attempted because of portal hypertension and G-I bleeding. One patient died of liver carcinoma 5 years after surgery. Because of the serious complications in HAE for benign hepatic lesions, re-evaluation of the rationale of such kind of treatment should be undertaken.

Hepatic resection and bile duct injury Injury to the extrahepatic bile duct during hepatic surgery occurred most frequently in operations for those lesions located in the perihilar region. Operations involving resection of tumors of quadrate lobe of the liver are most vulnerable because of the close proximity of these structures. Bile duct injury and stricture formation following hepatic resection should deserve more scrutiny because of its detrimental effect on the outcome of the surgery and the difficulty of repairing operation under such situation^[50-52]. In our experience, bile duct stricture resulting from hepatic surgery has become more common over the past 10 years, the increase of number of patients kept pace with the development and propagation of hepatic surgery in our country. In this report, bile duct injury in hepatic surgery accounted for 0.82%-15.7% of the total bile duct strictures. Furthermore, bile duct injuries occurred only in cases of hepatic trauma in Group A. In Group B, the incidence of bile duct injuries rose to 15.7 % as a result of resection of hepatic tumors. In fact, to our knowledge, numbers of bile duct injury in hepatic surgery were much larger than what was reported. The apparent reason is that many cases were recorded and filed as 'operative complications' or 'bile fistulae' instead of the diagnosis of traumatic bile duct injuries^[53-55]. Injury to the hilar bile duct is most vulnerable during resection of tumors, either benign or malignant, of the quadrate lobe of the liver. The transverse portion of the left hepatic duct courses along the underneath border of the quadrate lobe and with its peribiliary connective tissue fibers interwoven with that from the hilar plate. Identification and isolation of the left hepatic duct may be difficult especially when the normal anatomical relationship was distorted by local tumor growth. Furthermore, branches of bile duct to the left middle segment of the liver were difficult to be identified and individually divided, laceration injury of the left hepatic duct may occur when the hepatic tumor mass was mobilized. Therefore, we emphasized that technique of mobilizing the left hepatic duct with the hilar

plate for the prevention of bile duct injury should be a safeguard measure in liver resection and should be followed in case of perihilar tumor resection.

In recent years, a kind of small incision (3cm-5cm) cholecystectomy (minilaparotomy) has been introduced^[56-58]. The result of such type of operation is not different from that of conventional surgery so far as the probability of bile duct injury is concerned.

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