Original article

Long-term results and risk factors influencing outcome of major bile duct injuries following cholecystectomy

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Background: **Major bile duct injuries usually need operative repair and remain a challenge even for surgeons who specialize in hepatobiliary surgery. The purpose of this study was to evaluate management and short- and long-term outcomes of patients with major complications after cholecystectomy.**
Methods: **Data were analysed for 54 patients who underwent operation for major bile duct injuries after cholecystectomy between January 1990 and January 2002. Univariate and multivariate analyses were performed to identify risk factors for the development of biliary complications.**
Results: **Complete follow-up data were available for all 54 patients (median duration 61·9 (range 2·6–154·3) months). All underwent Roux-en-Y hepaticojejunostomy. Three patients (6 per cent) died from biliary tract complications during follow-up. Long-term biliary complications occurred in ten patients (19 per cent). Nine patients developed biliary stricture of whom five developed secondary biliary cirrhosis. A successful long-term result was achieved in 50 (93 per cent) of 54 patients, including those who required subsequent procedures. Biliary reconstruction in the presence of peritonitis ($P = 0·002$), combined vascular and bile duct injuries ($P = 0·029$), and injury at or above the level of the biliary bifurcation ($P = 0·012$) were significant independent predictors of poor outcome.**
Conclusion: **Successful repair of bile duct injuries after cholecystectomy can be achieved in specialized hepatobiliary units.**

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Introduction

The most common cause of benign biliary stricture is iatrogenic bile duct trauma during cholecystectomy[1,2]. With the widespread use of laparoscopic cholecystectomy, the rate of iatrogenic bile duct injuries has increased over the past decade. Despite the expertise gained worldwide in performing this procedure, the overall incidence of injury to the bile duct is approximately twice as high as that following open cholecystectomy[3–6]. These injuries cause significant morbidity and mortality, and also have a significant economic impact[7].

To determine appropriate management, it is essential to define the type of bile duct injury. The authors have previously proposed a classification system to cover the whole spectrum of possible lesions, including the mechanism, extent, level and diagnostic interval of injury after cholecystectomy[8]. Minor injuries, such as leakage from the cystic duct or common bile duct and short strictures, can often be managed endoscopically but surgical reconstruction is needed for major biliary complications[9–11].

The aim of this study was to analyse the management, and short- and long-term results of Roux-en-Y hepaticojejunostomy reconstruction for major bile duct injuries and strictures. Factors determining the success or failure of the treatment were identified.

Patients and methods

Between January 1990 and January 2002, 54 consecutive patients with bile duct strictures or major bile duct lesions underwent Roux-en-Y hepaticojejunostomy. Demographic data, and results of diagnostic and therapeutic procedures before and after referral, including laboratory results and imaging studies, were obtained for all patients. Follow-up evaluation took place at 1, 6 and 12 months, and on

an annual basis thereafter unless indicated sooner on the basis of clinical concern. The duration of follow-up was calculated from the date of the last intervention. The median duration of follow-up was 61·9 (range 2·6–154·3) months.

Short-term biliary complications were defined as events that required treatment, a prolonged hospital stay or readmission to hospital within 30 days after treatment at this institution. Events occurring more than 30 days after treatment were defined as long-term biliary complications.

Injury classification

Bile duct injuries were categorized according to the initial lesion after cholecystectomy, using the classification proposed by the authors[8] (*Fig. 1*). Patients with a minor leak from the gallbladder bed or cystic duct (type A) were excluded. Major bile duct injuries included occlusion by clips (type B), lateral lesions (type C), complete transections (type D) and late strictures of the extrahepatic bile ducts (type E). The level of injury in relation to the biliary bifurcation was recorded, along with the nature of any associated vascular damage.

Surgical management

Surgical reconstruction was generally performed as an elective procedure, except in 13 patients with biliary sepsis. When sepsis could not be managed by percutaneous or endoscopic intervention, surgery was performed regardless of acute inflammatory changes, abscess formation or changes in liver function. The standard surgical treatment was end-to-side Roux-en-Y hepaticojejunostomy with placement of one to three transhepatic silicone tubes, depending on the number of anastomosed bile ducts. Intraoperative cholangiography was not performed routinely. Hepaticojejunostomy employing a 40–60-cm Roux-en-Y jejunal loop was performed with 5/0 to 7/0 polydioxanone (PDS®; Ethicon, Hamburg, Germany) sutures. The transhepatic tubes were connected to external drainage until day 5 after surgery, when cholangiography was performed. If no leaks were found, the tubes were closed and left in place for 3 months. Systemic antibiotics (third-generation cephalosporins in combination with metronidazole) were given for 5 days.

Statistical analysis

Univariate analysis was performed using the Pearson χ^2 test and Fisher's exact test. Stepwise logistic regression analysis was carried out to identify the independent predictors of a biliary complication. Life-table analysis with the Kaplan–Meier method was employed to estimate survival without major biliary complications. $P < 0{\cdot}050$ was considered statistically significant. All statistical analyses were performed with the statistical software package SPSS® version 10.0 (SPSS, Chicago, Illinois, USA).

Results

Fifty-four patients underwent Roux-en-Y hepaticojejunostomy for bile duct complications after laparoscopic or conventional cholecystectomy. There were 30 women and 24 men (mean age 50·9 years). Two patients underwent additional hemihepatectomy. Occlusion of the common bile duct occurred in five patients (9 per cent), lateral lesions in 14 (26 per cent), complete transections in 24 (44 per cent) and late strictures in 11 (20 per cent). Eleven (20 per cent) of the 54 patients had a concomitant right hepatic arterial injury. Twenty-two patients (41 per cent) had one or more attempts at repair by the primary surgeon before referral, including hepaticojejunostomy (seven), end-to-end choledochocholedochostomy (eight), bile duct suture (four) and operative drainage of a biloma (three).

Survival

Five (9 per cent) of the 54 patients died during the follow-up period. Three deaths were due to biliary tract complications (multiorgan failure at 2 months, pulmonary embolism at 7 months and cholangiocarcinoma at 56 months after surgical repair). The other two patients died from bronchial carcinoma and acute pancreatitis at 32 and 54 months respectively after surgical repair.

Biliary complications

The incidence of short-term biliary complications was 19 per cent (ten of 54). Four patients with postoperative cholangitis were treated with antibiotics. One patient with a subhepatic fluid collection was treated successfully by percutaneous drainage. Bile leak after hepaticojejunostomy was observed in five patients. This resolved spontaneously in three patients, one required operative repair and the other developed an hepatic abscess leading to a systemic inflammatory response syndrome, multisystem organ failure and death.

The overall incidence of long-term biliary complications was 19 per cent (ten of 54 patients). Nine patients (17 per cent) developed a stricture at the biliary–enteric anastomosis. Five of these went on to develop secondary

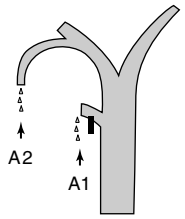
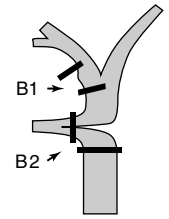
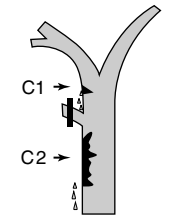
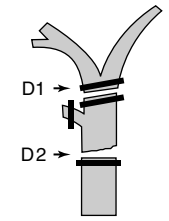
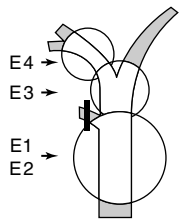
Type A	Peripheral bile leak (in communication with the CBD) A1 Cystic duct leak A2 Bile leak from the liver bed	
Type B	Occlusion of the CBD (or right respectively left hepatic duct, i.e. clip, ligation) B1 Incomplete B2 Complete	
Type C	Lateral injury of the CBD C1 Small lesion (<5 mm) C2 Extended lesion (>5 mm)	
Type D	Transection of the CBD (or right hepatic duct not in communication with the CBD) D1 Without structural defect D2 With structural defect	
Type E	Stenosis of the CBD E1 CBD with short stenosis (<5 mm) E2 CBD with long stenosis (>5 mm) E3 Confluence E4 Right hepatic duct or segmental duct	

Fig. 1 Neuhaus classification of bile duct injuries after cholecystectomy. From Neuhaus *et al.*[8], with permission. CBD, common bile duct

biliary cirrhosis, one of whom developed a cholangiocarcinoma and died 56 months after reconstruction. The five patients who developed secondary biliary cirrhosis had undergone at least one previous attempt at repair before referral and two of these required orthotopic liver transplantation 12 and 36 months after hepaticojejunostomy. At a median follow-up of 61·9 (range 2·6–154·3) months, 50 of 54 patients had a successful outcome, including

Table 1 Univariate and multivariate analysis of factors predicting major biliary complications after hepaticojejunostomy for repair of bile duct injury after cholecystectomy

Predictors of outcome	Proportion with major biliary complications	*P* (Univariate analysis)	*P* (Multivariate analysis)
Laparoscopic cholecystectomy	10 of 44	0·667	—
Injury at or above the bifurcation	9 of 24	0·007	0·012
Previous repair	7 of 22	0·028	0·063
Peritonitis at repair	7 of 13	0·002	0·002
Combined bile duct and vascular injury	5 of 11	0·035	0·029

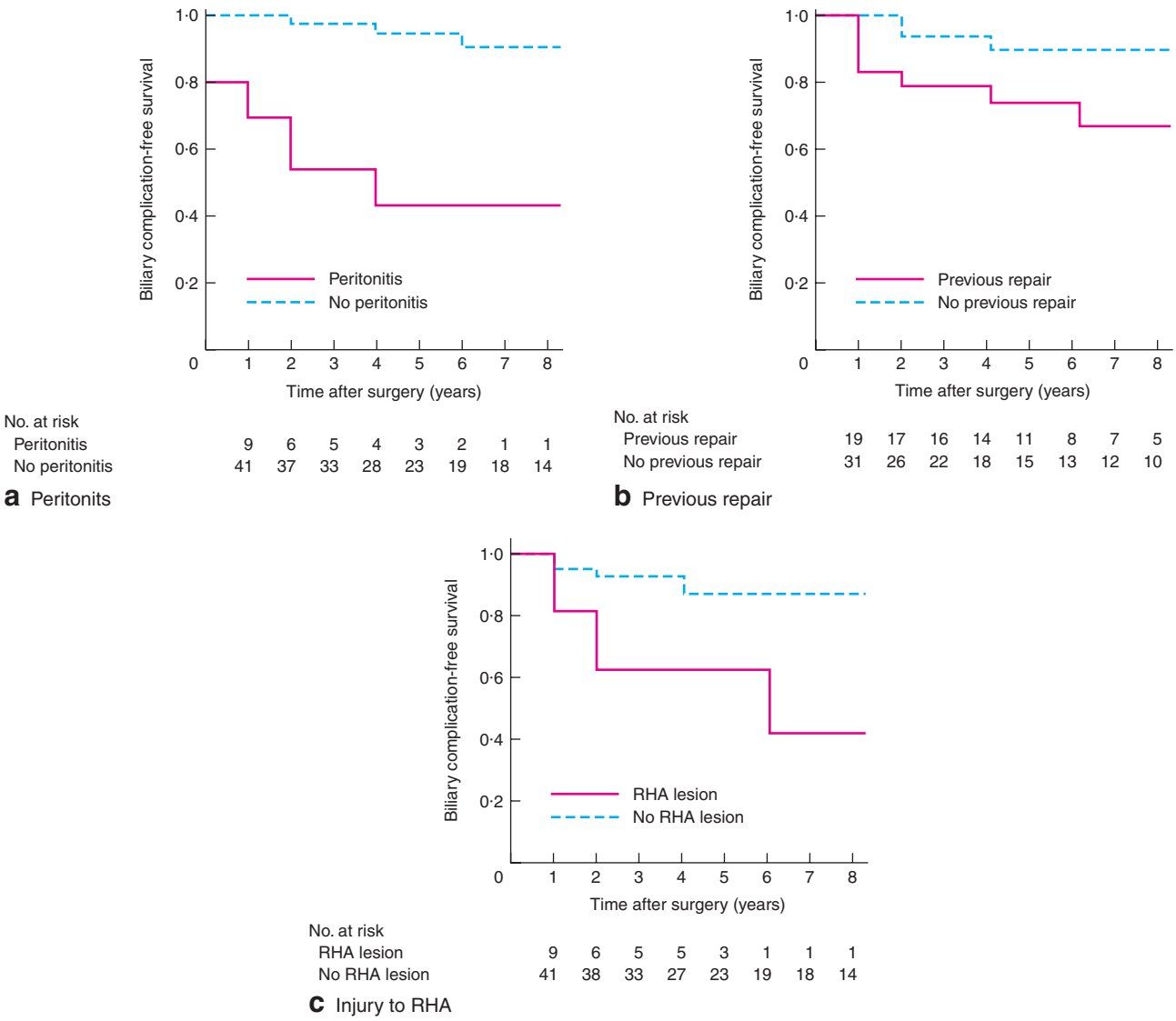


Fig. 2 Cumulative biliary complication-free survival after hepaticojejunostomy as treatment for bile duct injury according to the presence of **a** active peritonitis ($P < 0·001$), **b** previous operative repair ($P = 0·050$) and **c** concomitant injury to the right hepatic artery (RHA) ($P = 0·004$). Log rank test was used for statistical analysis

those who required additional endoscopic or surgical treatment.

On univariate analysis, four factors were associated with the development of major biliary complications (*Table 1*): surgical repair in the presence of active peritonitis ($P = 0{\cdot}002$), injuries at or above the biliary bifurcation ($P = 0{\cdot}007$), previous surgical repair ($P = 0{\cdot}028$) and bile duct injury with concomitant right hepatic arterial injury ($P = 0{\cdot}035$). Multivariate analysis with stepwise logistic regression identified repair in the presence of peritonitis ($P = 0{\cdot}002$), high injuries ($P = 0{\cdot}012$) and concomitant vascular injuries ($P = 0{\cdot}029$) as independent risk factors.

Cumulative biliary complication-free survival curves are shown in *Fig. 2*.

Discussion

The most common benign lesions of the bile duct wall are those resulting from iatrogenic injury sustained during the course of cholecystectomy[1,2]. Since the widespread introduction of laparoscopic cholecystectomy, the rate of bile duct injury has at least doubled, to one in 200–300 operations worldwide[9]. From a worldwide database of thousands of patients from many institutions, the incidence of major bile duct injury after laparoscopic cholecystectomy was reported to be 0·16–2·35 per cent[10]. In contrast, the rate of such lesions resulting from open cholecystectomy ranges from 0·07 to 0·9 per cent[10]. This difference was initially explained by the 'learning curve' effect attributed to the acquisition of a new surgical technique. Despite worldwide expertise in the procedure, reports from Australia and the USA have demonstrated no decline in the annual incidence of bile duct injuries with time[4,10]. A number of risk factors for the occurrence of bile duct injuries have been well described, including severe inflammation, bleeding, anatomical variations and lack of surgical experience[8]. Most reported injuries have occurred as a result of inadvertent division of the common or hepatic bile duct (misidentified as the cystic duct), uncontrolled clipping or the liberal use of diathermy. Major bile duct injury is a serious and potentially life-threatening complication. Cholecystectomy-related bile duct injuries may also have severe financial implications, with costs being 4·5–26·0 times higher than those of an uncomplicated procedure[7].

The goal of surgical repair of the injured biliary tract is the restoration of a durable bile conduit, and the prevention of short- and long-term complications such as biliary fistula, intra-abdominal abscess, biliary stricture, recurrent cholangitis and secondary biliary cirrhosis. The diagnostic evaluation of patients with biliary injuries should include accurate delineation of the biliary anatomy. Suspected intra-abdominal abscess formation or vascular injury can be detected by computed tomography or magnetic resonance cholangiography. The importance of preoperative delineation of the biliary anatomy was demonstrated by Stewart and Way[12]: the majority of patients who had bile duct repair without cholangiography (96 per cent) or with incomplete cholangiographic data before surgery (69 per cent) had an unsuccessful outcome. In contrast, surgical repair was successful in 84 per cent of patients in whom cholangiographic data were complete.

Appropriate operative repair depends on the type of injury. Extended lateral lesions, for instance, are often amenable to direct suture over a T tube. Complete transections with no loss of ductal length diagnosed during surgery can be treated by end-to-end ductal repair over a T tube when the edges of the transected bile duct are fresh and well vascularized. This type of repair is, however, associated with a high rate of restructure[12], probably owing to underestimation of ischaemic damage to the biliary tract[9,12]. Most complete transections are associated with loss of a segment of the bile duct. In this situation, a tension-free end-to-end anastomosis of the bile duct is rarely possible, even if the duodenum has been mobilized. For these reasons, an end-to-side hepaticojejunostomy in a mucosa-to-mucosa technique with a 40-cm Roux-en-Y jejunal loop is the preferred procedure[8,9,13]. Some bleeding should be visible from the cut edge of the bile duct. Whether the left duct is incised to widen the anastomosis will depend on the individual situation[14]. Temporary stenting and bile diversion from the anastomosis remains controversial. Those who favour stenting and decompression of the biliary tree claim a lower probability of postoperative stricture[15,16]; others have found equivalent results without stenting[14,17]. Stenting carries a risk of prolonged cholangitis but it ensures a minimum size of the anastomosis as healing occurs and inflammation settles, and allows easy access for diagnostic and therapeutic intervention.

Before the introduction of laparoscopic cholecystectomy, successful long-term results were reported in 80–95 per cent of patients undergoing operative repair of biliary strictures at tertiary referral centres[17–20]. Similar results have been obtained in patients having surgery for injuries resulting from laparoscopic cholecystectomy[16,18,21–23]. The overall success rate in the present series was 93 per cent. However, the rate of long-term biliary complications was 19 per cent. Analysis of the long-term outcome of patients after hepaticojejunostomy identified three factors that influence the success or failure of surgical repair: the presence of active peritonitis at the

time of repair, the combination of bile duct and vascular injury, and a level of injury at or above the biliary bifurcation. These factors were associated with a significantly higher risk of developing severe biliary complications such as hepatic abscess, anastomotic stricture or secondary biliary cirrhosis.

In the present series, attempts at repair by the primary surgeon who performed the cholecystectomy were successful in only 17 per cent of patients. In contrast, when the first repair was performed by a surgeon experienced in hepatobiliary surgery, the success rate was 94 per cent. Similar results were reported by Johnson *et al.*[24], who found significant hepatic fibrosis in 31 per cent of patients after delayed referral.

Several authors have recommended long-term external drainage of the biliary tree and subhepatic abscess formation to control sepsis and any biliary leak in patients with either peritonitis or intra-abdominal fluid collections[10,25,26]. This strategy may be associated with prolonged hospital stay, pain and inconvenience to the patient, and for these reasons early surgical intervention with bilioenteric anastomosis and transhepatic duct stenting was preferred in the present study. Although this approach increases the risk of restenosis, a secondary surgical repair may still be performed at a later date.

Very few data are available regarding combined bile duct and vascular injuries. In a large autopsy series[27], hepatic artery injury was observed in 7 per cent of patients who had previously undergone open cholecystectomy. A recent study by Buell *et al.*[28] identified a concomitant hepatic arterial lesion in 13 of 49 patients with postcholecystectomy bile duct injury. Koffron *et al.*[29] found concomitant arterial disruption in 11 of 18 patients with failed primary management of iatrogenic bile duct injury after laparoscopic cholecystectomy. In the series of Gupta *et al.*[30], four of 13 patients had combined bile duct and hepatic arterial injuries. Bachellier *et al.*[31] observed three vasculobiliary injuries in 15 patients, and Madariaga *et al.*[32] identified a concomitant hepatic artery injury in five of 14 patients with bile duct injury after laparoscopic cholecystectomy.

The present study has highlighted the clinical significance of combined bile duct and right hepatic artery injuries. Similar observations have been made by other groups[28,30–34]. The results indicate that concomitant arterial injuries have an adverse influence on the outcome of biliary injury. Based on available data, assessment of the hepatic arterial system, particularly by computed tomography, should always be performed in patients with major bile duct injury and vascular reconstruction considered whenever feasible.

Although a successful overall outcome was achieved for the majority of patients in this and other series, restenosis of the biliary enteric anastomosis years after operative repair cannot be excluded. Two-thirds of recurrences occur within the first 2 years but stricture recurrence after 10 years has also been reported[23]. The long interval from reconstruction to symptomatic late stricture and liver failure underlines the need for long-term follow-up. Liver transplantation – the ultimate option for patients with biliary tract lesions and which was necessary for two patients in the present series – should then be a rare event.

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