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ORIGINAL PAPER

Long-term results of secondary biliary repair for cholecystectomy-related bile duct injury: results of a tertiary referral center

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ABSTRACT

Background: Management of bile duct injury (BDI) after cholecystectomy is challenging. The authors analyzed their center's 49-year experience.

Methods: From 1968 to 2016, 120 consecutive patients were managed in a tertiary HBP center, 105 referred from other centers (Group A), 15 from our center (Group B). Surgical strategies and long-term outcomes were retrospectively reviewed.

Results: Primary cholecystectomy approach was open in 35% and laparoscopic in 65%. In Group A, intraoperative BDI diagnosis was made in 25/105 patients, including 13 via intraoperative cholangiography (IOC) which was used in 21% of cases. Median time from BDI to referral was 148 days (range 0–10,758), and 3 patients had BDI-related secondary cirrhosis. Ninety-four patients underwent secondary surgical repair, mostly a complex biliary procedure (97%). Postoperative overall and severe morbidity rates were 26% and 6%, respectively. One patient with biliary cirrhosis at referral died postoperatively from hepatic failure. Nine patients (9.6%) developed a secondary biliary stricture after a median of 54 months from repair (6–228 months). In Group B, IOC was performed in 14/15 in whom BDI were intraoperatively detected and immediately repaired. There were 13 minor and 2 major BDIs, all repaired by uncomplex procedures with uneventful postoperative course. One patient had a secondary biliary stricture after 5 months, successfully treated by temporary endoprosthesis.

Conclusion: Late follow-up after primary or secondary repair of BDI is recommended to detect recurrent biliary stricture. Bile duct injuries may occur in a tertiary center, but are intraoperatively detected with routine IOC and immediately repaired resulting in satisfactory outcome.

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Bile duct injury; surgical repair; cholecystectomy; intraoperative cholangiography

Introduction

Managing post-cholecystectomy bile duct injury (BDI) is challenging. Indeed, BDI carries high mortality and morbidity, which can be devastating, leading to poor quality of life, high litigation rates and tremendous healthcare costs [1–3]. Laparoscopic cholecystectomy (LC) emergence originally led to increased BDI (prevalence: 0.4–0.6%) [4,5]. However, current laparoscopic BDI prevalence rates have settled around those of open cholecystectomy, i.e. 0.3% [6,7], although LC-BDIs tend to occur more proximally, with more severe lesions like injuries of the biliary confluence or the right hepatic artery [8].

Ideal BDI-repair timing should be either immediate or delayed, not intermediate: if BDI is undiagnosed during initial cholecystectomy, it is preferable to wait several weeks for peritoneal and local inflammation regression and bile ducts' dilatation [9–11].

Long-term outcome after BDI surgical repair depends on intraabdominal infection or inflammation subsidence, number of repair attempts, BDI level and severity, timing and biliary surgeons' expertise [9,12]. Following reconstruction, long-term follow-up is needed to detect recurrent anastomotic biliary strictures, whose reported prevalence is 10–30%, sometimes more than 10 years post-BDI repair [11,13,14]. However, very few studies report long-term follow-ups. The present study therefore aimed to review retrospectively our experience of cholecystectomy-related BDI and to analyze long-term outcome following final biliary repair.

Patients and methods

From 1968 to 2016, 120 consecutive patients were managed for cholecystectomy-related BDI either as

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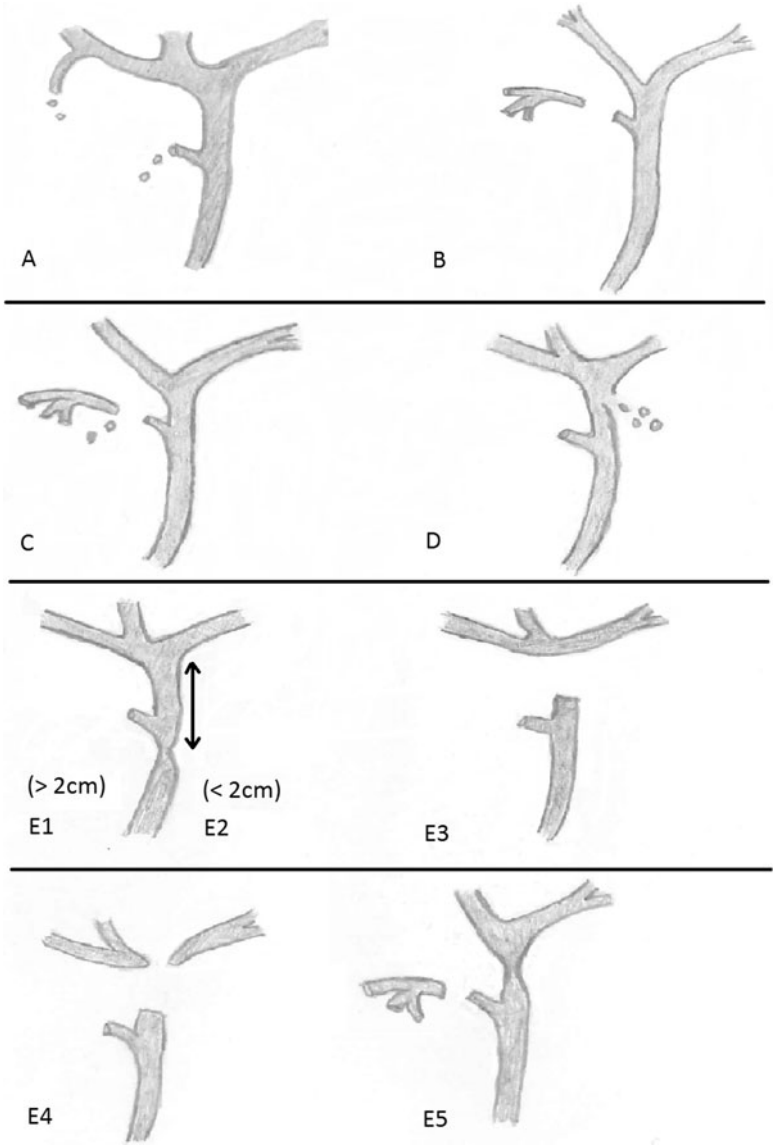

Figure 1. Strasberg classification of bile duct injury. Type A injuries are bile leaks from the cystic duct or leaks from small ducts in the liver bed. Type B and C injuries involve occlusion or transection without ligation of the aberrant right hepatic ducts. Type D injuries are lateral injuries to common bile ducts, without loss of continuity. Type E injuries are subdivided according to the Bismuth classification. The notations >2 cm and <2 cm in type E1 and type E2 indicate the distance between the biliary bifurcation and the biliary injury.

referred patients (Group A) or as local patients (Group B) by the Hepato-Biliary and Pancreatic Surgical Unit of Cliniques universitaires Saint-Luc (Brussels, Belgium). Medical records of those patients were retrospectively reviewed. Patients directly addressed to the Gastro-Enterology department for successful endoscopic treatment were not included in the present study. BDI was defined as any extrahepatic biliary tree damage occurring during cholecystectomy. Trauma-related biliary injury and stricture, common bile duct stone choledochotomy, chronic pancreatitis, malignant disease, hepatectomy, liver transplantation and digestive surgery other than cholecystectomy were excluded. Routine preoperative diagnostic procedures included, when available, abdominal ultrasound, abdominal computed tomography, magnetic resonance cholangiopancreatography, endoscopic retrograde cholangiography and intraoperative cholangiography (IOC), to define biliary anatomy, detect concomitant vascular injuries and exclude intraabdominal fluid collections.

Bile duct injuries were differentiated using Strasberg's classification, based on surgical and cholangiographic findings (Figure 1) [15]. BDI type A, B, C or D was considered minor, while BDI type E was considered a major injury. Patients with bile leaks from the cystic stump or gallbladder bed (type A injury) were excluded from this study. Patients' operative risk and comorbidities were evaluated using the American Society of Anesthesiology (ASA) physical score. Postoperative surgical complications occurring during the first 30 days were graded using Dindo-Clavien's

classification [16]. Long-term follow-up usually included annual consultation, clinical evaluation, laboratory tests and imaging studies (before 1995: ultrasonography, after 1995: magnetic resonance cholangiography).

Surgical management

All BDI repairs were performed by expert HBP surgeons. BDI types B and C were treated by definitive clipping (injury to a small sectorial right hepatic duct) or hepaticojejunostomy with Roux-en-Y jejunal limb, BDI type D by direct suture and types E1–E5 by end-to-end biliary anastomosis in selected cases, by hepaticojejunostomy or Hepp-Couinaud repair (hepaticojejunostomy incorporating the left main hepatic duct's extrahepatic portion after lowering the hilar plate) without transanastomotic stent depending on BDI level [17] or by right hemihepatectomy in case of associated vascular injury with liver necrosis, sepsis or atrophy. Hepaticojejunostomy with or without Hepp-Couinaud approach and associated liver resection were considered complex repairs. Some referred patients were kept under observation without secondary surgical repair, following isolated or combined operative and/or nonoperative treatment at the initial hospital.

Timing of surgical repair was defined as 'immediate' when performed during cholecystectomy, 'early' when performed within 8 days, 'intermediate' 8 days to 8 weeks and 'late' beyond 2 months post-cholecystectomy.

Outcome measurements

BDI repair outcomes were graded using Mayo's score based on patients' clinical symptoms, liver function tests (LFTs) and needs of further interventions [18]. Patients were 'Grade A' if asymptomatic with normal LFTs, 'Grade B' if asymptomatic with mild LFTs alterations, 'Grade C' if symptomatic (pain or cholangitis) with abnormal LFTs, and 'Grade D' if endoscopic, radiological or surgical reinterventions were required for treating newly developed strictures. Additional asymptomatic late stricture of biliary repair and liver atrophy were also reported.

Statistical analysis

All data were expressed as mean or median values with range. We used chi-square with Cook's correction for dichotomous categorical variables, the chi-square test when comparing more than two categorical variables, Smirnov's test for comparing ordered variables and logistic regression for multivariate analysis. Log rank was used for the referral delay. Estimation of the 10% stenosis time was obtained with the accelerated failure time using Weibull's model. Two-sided $p \leq .05$ was considered statistically significant.

Results

In this 49-year retrospective study, 105 referred BDI from other hospitals (Group A) and 15 local LC-related BDI (Group B) were included (Figure 2). The whole series sex-ratio was 0.4 (36 men/84 women). Patients' demographics and characteristics are reported in Table 1, BDI diagnosis and initial management in Table 2.

Group A: referred BDIs

The annual recruitment of patients suffering cholecystectomy-related BDIs (Figure 3) rose in the nineties with LC's introduction in Belgium.

Initial cholecystectomy and postoperative management

Primary cholecystectomy's indications, when recorded, were mainly uncomplicated gallstones (41.0%), and its approach was laparoscopy (42.9%), conversion to laparotomy (20.0%) or primary open (37.1%). Intraoperative BDI diagnosis was made in 25 patients (24.0%), including 13 via IOC. Prior to referral, 62 patients (59.0%) had various immediate or early repair attempts: direct suture ($n = 20$), end-to-end anastomosis ($n = 5$), hepaticojejunostomy ($n = 27$) or radiological/endoscopic stenting ($n = 19$). Time from BDI to referral to our center was variable, with a median interval of 148 days (0–10,758 days). Thirty-nine patients (37.1%) were referred within 2 months post-cholecystectomy for biliary peritonitis ($n = 2$), bile leakage ($n = 15$), jaundice ($n = 10$), cholestasis ($n = 2$) or cholangitis ($n = 3$); 7 patients were asymptomatic. The remaining 66 patients were referred after 2 months for signs of biliary stricture (26 with jaundice, 30 with cholangitis), abdominal pain ($n = 2$) or chronic biliary leak ($n = 4$); 4 patients were asymptomatic. Three of these 66 patients (4.5%) had secondary biliary cirrhosis related to chronic biliary fistula ($n = 1$) and chronic cholangitis ($n = 2$).

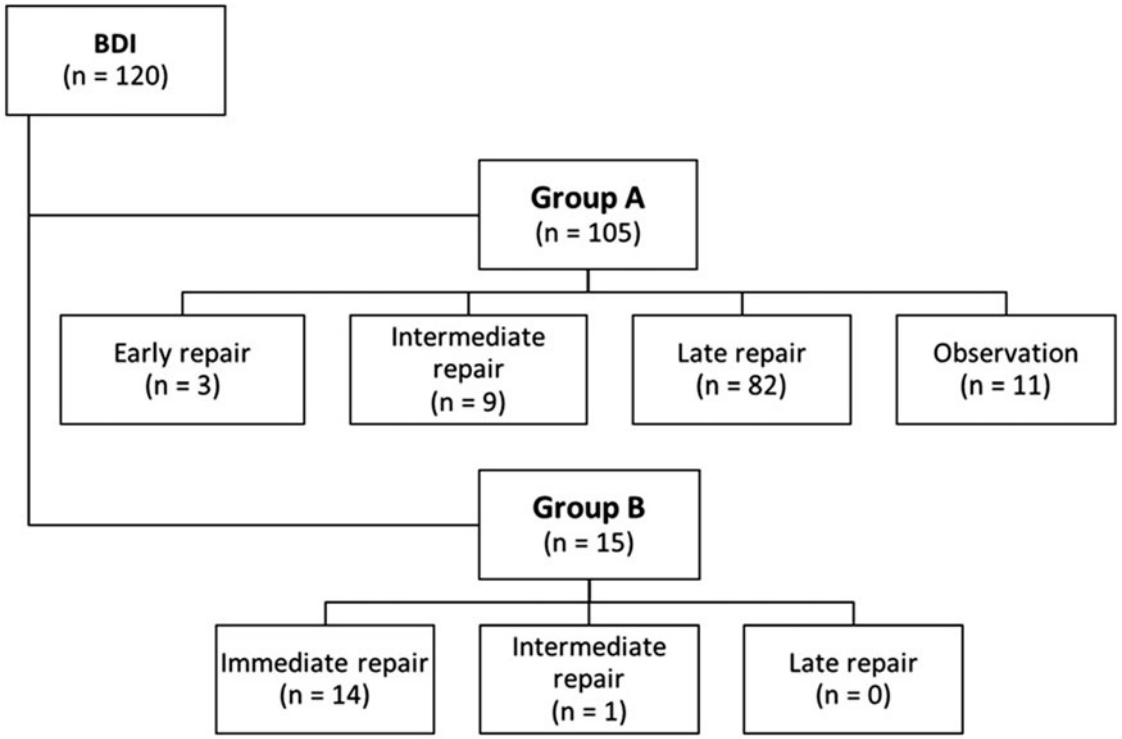

Figure 2. Flow chart of patients' recruitment. BDI: bile duct injury.

Table 1. Patients' characteristics.

Patients, characteristics	Total	Group A	Group B
Number of patients (*n*)	120	105	15
Age (years), median (range)	51 (23–82)	48 (23–82)	63 (28–76)
Gender ratio: male/female (*n*)	36/84	29/76	7/8
ASA score, *n* (%)			
I or II	102 (85.0%)	91 (86.7%)	11 (73.3%)
III or IV	18 (15%)	14 (13.3%)	4 (26.6%)
Indications for cholecystectomy, *n* (%)			
Uncomplicated biliary lithiasis	44 (36.7%)	43 (41.0%)	–
Acute/chronic cholecystitis	57 (47.5%)	43 (41.0%)	15* (100%)
Stone migration	6 (5.0%)	6 (5.7%)	–
Unknown	13 (10.8%)	13 (12.4%)	–
Cholecystectomy approach, *n* (%)			
Open	42 (35.0%)	39 (37.1%)	3 (20.0%)
Laparoscopic (LC)	78 (65.0%)	66 (62.9%)	12 (80.0%)
LC converted to Open	26	21	5
(% of LC and % of n of column)	(33.3%, 21.7%)	(31.8%, 21.0%)	(41.7%, 33.3%)

*Including 4 patients with stone migration.
ASA: American Society of Anesthesiology.

Severity of BDI and management

There were 3 minor BDI (type B, C or D), and 102 major BDI including 40 E1/E2-type, 31 E3-type, 11 E4-type and 20 E5-type among the 105 referred patients, 9 of whom had coexistent vascular injury. Eleven patients were put under observation (without any further surgical repair) whilst 94 underwent secondary surgical repair procedures (Table 3), mostly hepaticojejunostomy using Hepp-Couinaud's approach (70.2%). Four patients (4.3%) underwent associated right hemihepatectomy for complex E4 or E5 lesions with coexistent vascular injury in 3. The subgroup of 11 observed patients had undergone primary surgical repair: 6 by suture including 3 associated endoscopic stenting, 3 by hepaticojejunostomy including 1 with percutaneous biliary stenting, and 2 patients were untreated (1 with asymptomatic late incomplete right hepatic duct biliary stricture and liver atrophy, and 1 suffering from extensive extrahepatic and intrahepatic bile duct necrosis secondary to vascular damage).

Postoperative outcome

In the subgroup of 94 Group A repairs, postoperative complications occurred in 24 patients (25.5%), including 18 Dindo-Clavien grade 2 and 6 grade 3 complications (6.4%), all related to temporary anastomotic leakage. One 79-year-old patient died from hepatic failure after a successful hepaticojejunostomy (postoperative mortality: 1.1%), following referral for E1-type biliary stricture after failed

Table 2. Characteristics of diagnosis and initial management of bile duct injury.

	Total ($n = 120$)	Group A ($n = 105$)	Group B ($n = 15$)
Timing of BDI diagnosis, *n* (%)*			
Intraoperative	39 (32.5%)	25 (23.8%)	14 (93.3%)
Postoperative	81 (67.5%)	80 (76.2%)	1 (6.7%)
IOC, *n* (%)*	36 (30.0%)	22 (20.9%)	14 (93.3%)
Enabling BDI diagnosis	27	13	14
(% IOC, % column *n*)	(75%, 22.5%)	(59.1%, 12.4%)	(100%, 93.3%)
Concomitant vascular injury, *n* (%)	9 (7.5%)	9 (8.6%)	0
Prior repair attempt, *n**	75	75	0
(% repair, % column *n*)			
Direct suture	20 (26.7%, 16.7%)	20 (26.7%, 19.0%)	–
End-to-end anastomosis	5 (6.7%, 4.2%)	5 (6.7%, 4.8%)	–
Hepaticojejunostomy	27 (36.0%, 22.5%)	27 (36.0%, 22.7%)	–
Stenting	23 (30.7%, 19.2%)	23 (30.7%, 21.9%)	–
Referrals			
Within 2 months post-LC, *n* (%)*		39 (37.1%)	15
Median time (days, range)*		148 (0–10,758)	0
Symptoms on referral, *n* (%)			
No symptoms	11 (9.2%)	11 (10.5%)	–
Bile leakage	19 (15.8%)	19 (18.1%)	–
Bile peritonitis	2 (1.7%)	2 (1.9%)	–
Cholangitis	33 (27.5%)	33 (31.4%)	–
Jaundice or cholestasis	38 (31.7%)	38 (36.2%)	–
Secondary biliary cirrhosis	3 (2.5%)	3 (2.9%)	–

*Significant difference between Groups A and B ($p < .001$).
BDI: bile duct injury; IOC: Intraoperative cholangiography; LC: laparoscopic cholecystectomy.

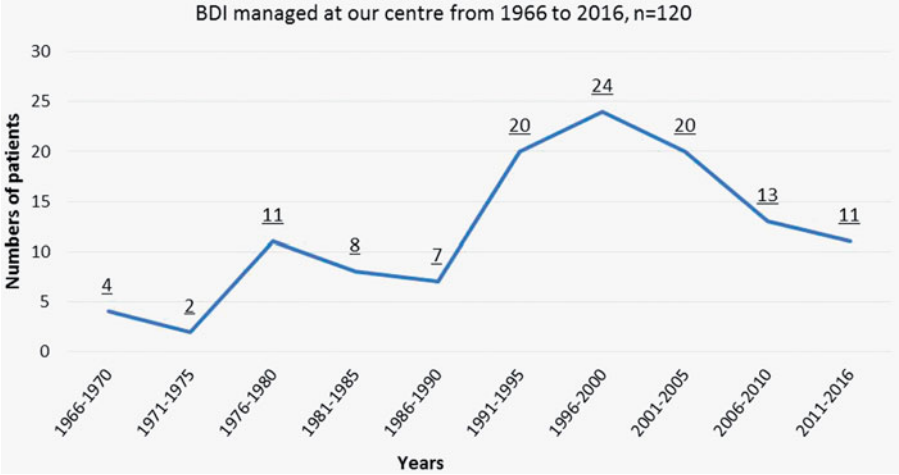

Figure 3. Patients managed at our center for bile duct injuries (BDI) over the past 50 years.

Table 3. Types of biliary repairs according to the Strasberg classification.

	Group A				Group B		
	Repaired				Repaired		
Strasberg classification	Early	Intermediate	Late	Observed	Immediate	Early	Late
Types B,C,D**	–	–	1HJ	2	10 S*2 clipping	1 S*	–
Type E**	1EE 2HJ	1S 8HJ	1EE 10 HJ 66 Hepp 2 RH 2 RH + HJ	9	1 S 1 EE	–	–
E1, E2	1 EE	1 S 4 HJ	1 EE 4 HJ 25 Hepp	4	–	–	–
E3	–	2 HJ	1 HJ 27 Hepp	1	–	–	–
E4	–	2 HJ	8 Hepp 1 RH + HJ	–	–	–	–
E5	2 HJ	–	6 Hepp 5 HJ 2 RH 1 RH + HJ	4	1 S 1 EE	–	–

Note. 'Early' repair when performed within 8 days after cholecystectomy, 'intermediate' from 8 days to 8 weeks and 'late' beyond 2 months.
S: Suture; EE: end-to-end anastomosis; Hepp: Hepp-Couinaud; HJ: hepaticojejunostomy; RH: right hemihepatectomy; BDI: bile duct injury.
*Suture combined with endoprosthesis in 4 patients.
**Significant difference comparing BDI type E (major) to types B, C and D (minor) ($p < .001$).

Table 4. Comparative final outcome according to the Mayo score for referred and local patients.

		Group A		
Final outcome	Total	Repaired*	Observed**	Group B
Grade A (excellent)	101	82 (88.2%)	6 (66.6%)	13 (86.7%)
Grade B (good)	4	3 (3.2%)	0	1 (6.7%)
Grade C (poor)	1	1 (1.1%)	0	0
Grade D (failure)	11	7 (7.5%)	3 (33.3%)	1 (6.7%)
Total	117	93	9	15

*Exclusion of 1 cirrhotic patient who died postoperatively from liver insufficiency.

**Exclusion of 2 patients who died after 2 months (one from septic shock due to complete biliary necrosis from associated vascular injury, one from coexistent metastatic pancreatic cancer diagnosed just after bile duct injury).

endoscopic treatment and secondary Child-Pugh C biliary cirrhosis. This subgroup's median postoperative hospital stay was 11 days (6–180 days).

In Group A's observation subgroup, 2/11 patients died after 2 months, one with necrosis of the whole biliary tree from associated vascular injury resulting in fatal septic shock, the other died from coexistent metastatic pancreatic cancer diagnosed just after BDI.

Follow-up

In Group A's subgroup of 93 referred biliary repair survivors, median follow-up time was 125 months (3–540 months). Satisfactory results (Mayo grade A/B) were encountered in 85/93 patients (91.4%), while poor outcomes (Mayo grade C/D) were observed in 8/93 patients (8.6%) (Table 4). Nine patients (9.6%) developed a secondary biliary stricture after a median of 54 months (6–228 months). These patients had a BDI type E without vascular injury, have been repaired more than 3 months after cholecystectomy with a hepaticojejunostomy (including with Hepp-Couinaud's approach in 7), without any major complication; except one patient having developed a temporary anastomotic leakage. Treatment of recurrent biliary stricture included 6 successfully percutaneous transhepatic biliary stentings and 1 right hemihepatectomy; no liver atrophy was observed. The remaining 2 patients with anastomotic stricture did not require treatment because of absent clinical and biological symptoms. Five patients presented hemiliver atrophy without symptoms nor associated anastomotic stricture for 4 of them (BDI type E3 in 2, type E4 in 1 and type E5 in 5), whilst one patient with BDI type E3 developed a symptomatic biliary stricture treated by percutaneous stenting.

In Group A's subgroup of 9 observed survivors, median follow-up time was 93 months (14–272 months), 6 had a Mayo score grade A and 3 grade D. A biliary stricture appeared in 4 and was successfully treated either endoscopically or radiologically for 3 of those without recurrence or sequelae in the liver. Two among the 9 surviving observed patients developed asymptomatic hemiliver atrophy, including one patient with ipsilateral biliary stricture.

Comparison between open and laparoscopic cholecystectomy-related BDI

Open and laparoscopic cholecystectomy-related BDI patients were not significantly different regarding to patients' characteristics, IOC use, timing of BDI diagnosis, BDI type, symptoms at referral and repair timing. There were significant differences in terms of repair procedures attempted before referral, with fewer direct biliary sutures in patients with open cholecystectomy (1/38 vs. 13/56, $p = .006$). In addition, laparoscopy patients had undergone more biliary stenting prior to referral (1/38 vs. 14/56, $p = .004$), their median time to referral was also significantly shorter (115 vs. 312 days, $p < .001$). Late outcome according to the Mayo score was not significantly different neither was the recurrent biliary stricture rate.

Comparison of results according to timing of repair

There were no significant differences between patients operated 'early or intermediately' post-cholecystectomy and those operated 'late' regarding patients' characteristics, timing of BDI diagnosis, BDI type and previous procedures before referral. Symptoms at referral were significantly different, with more bile peritonitis in the early/intermediate group (2/12 vs. 0/82, $p = .004$) and more cholangitis (33/82 vs. 0/12, $p = .007$) in the late group. However, late outcomes according to the Mayo score were not significantly different among survivors neither were recurrent biliary stricture rates.

Univariate and multivariate analysis

In our study's Group A's subgroup of referred repaired patients, the logistic regression did not identify independent prognostic factors of biliary stricture or poor outcomes (Mayo grades C/D).

Group B: local patients suffering from BDI

Incidence

From 1994 (date of first local BDI) to 2016, the incidence of cholecystectomy-related BDI at our teaching hospital was 0.27% (15/5636 cholecystectomies), for an annual number of 470 cholecystectomies per year.

Initial cholecystectomy

Among the 15 BDI cases occurring within our department (Figure 2), indications for cholecystectomy were acute or scleroatrophic cholecystitis (93.3%), 6 of which presented coexistent right biliary anomalies and 1 Mirizzi syndrome. One patient had an open cholecystectomy during an emergency gastrectomy for gastric ulcer perforation, as there was an associated necrotic gallbladder. Laparoscopy was the most frequent approach in 80.0% of patients. During surgery, IOC was performed in all cases except for one delayed cholecystitis patient whose cystic duct was too thin and fragile for catheterization. Intraoperative BDI diagnosis was possible in 14/15 patients with immediate repair, while the patient without IOC underwent intermediate repair for bile peritonitis from a type D thermal injury.

Severity of BDI and management

According to Strasberg's classification, there were 13 minor BDI (86.7%) and 2 major BDI (E5-type). All repairs were accomplished by direct suture combined or not with endoprosthesis ($n = 12$), by end-to-end biliary anastomosis ($n = 1$) or by definitive clipping of a small right sectoral duct ($n = 2$) (Table 2). No postoperative complication nor death occurred in Group B.

Follow-up

During a median follow-up time of 44 months (4–269 months), final outcome was satisfactory in 14 patients (93.3%). The remaining patient (with direct suture of a right sectoral duct) developed a secondary biliary stricture after 5 months, successfully treated by temporary endoprosthesis and excellent outcome 230 months later.

Discussion

The present study reports a tertiary HPB center's experience with respect to surgical repair of both local and referred cholecystectomy-related BDI, with satisfactory long-term outcome in over 90% of patients during a median follow-up of 10 years, with low severe morbidity and mortality rates. The referred patients' clinical history included mostly postoperative BDI diagnosis, previous management attempts and a long delay prior referral before definitive complex repair of major BDI. By contrast, case reports of BDI occurring within our teaching HPB center – which has a routine policy of using and adequately interpreting IOC – were few, immediately diagnosed and repaired with excellent outcome. Finally, the very long-term follow-up after biliary repair allows us to identify late recurrent strictures.

Outcome success after biliary repair reportedly depends on several factors, including timing of surgical repair, number of prior repair attempts before referral and the repair surgeon's expertise [9–13,19,20]. Timing of biliary repair is still debated, some major series advocating late repair to maximally reduce intra-abdominal infection and inflammation, whilst waiting for the suprastenotic bile ducts dilatation before definitive surgical biliary repair. This attitude was adopted in many tertiary centers, including ours, with satisfactory patient outcome. De Reuver et al. reported a 10% long-term biliary stricture rate following repair at their referral center, strictures occurring more often in patients operated within 6 weeks post-BDI and in those with previous surgical, endoscopic or radiologic interventions [19]. In the present series, the primary general surgeons with less HBP experience attempt to restore the biliary tree post-BDI in 59% of the patients. But each unsuccessful biliary repair damages and shortens the healthy bile duct, thereby increasing the technical challenge of secondary biliary reconstruction. Stewart and Way reported a 91% surgical BDI repair success rate when performed in an expert center, compared to 13% when performed by the initial surgeon. There was no correlation between biliary repair timing and outcome, but they highlighted the key policy of sepsis and inflammation control [12]. In the present series, the median delay to referral was particularly long and most biliary repairs were undertaken in the late period. Satisfactory results were encountered for 91.4% of referred patients with a low secondary biliary stricture rate (9.6%).

Surgical biliary repair is technically challenging and postoperative complications can worsen long-term outcome [14]. In our series of referred patients treated by surgical repair, postoperative morbidity rate was 25.5%, including major complications related to temporary anastomotic leakage

(6.4%) and a 1.1% mortality rate. These results are similar to other series reporting morbidity rates of 23–36% with 0–4% mortality rates [11,13,21]. Sicklick et al. reported a 43% complication rate at John Hopkins, but they also included minor complications managed conservatively [22], which suggests that surgical management of BDI remains delicate even in expert centers and for 'late' repairs, justifying the need for patients' referral to experienced centers.

Most biliary repairs in our study's referred cases consisted in complex repairs, including hepaticojejunostomy and Hepp-Couinaud's approach without stenting in 92.6% of patients; end-to-end anastomosis was performed in few selected minor BDI with satisfactory outcome. Indeed, duct-do-duct biliary anastomosis should be used carefully when the bile duct is large, well-vascularized, without inflammation and without extensive tissue loss [23]. Many of our patients were referred for Strasberg's type E-BDI or following prior repair attempts and we therefore mostly performed bilioenteric anastomoses. Forty years ago transhepatic intubation of the hepaticojejunostomy with Silastic tube stenting was described resulting in absence of long-term biliary strictures [24]. But this technique became progressively debatable when experienced groups showed good outcomes without biliary stents [25]. In our experience, biliary repairs were performed without stenting and we observed a low rate of both early and late biliary complications. Using Hepp-Couinaud's approach of an extended left hepaticojejunostomy enables a wide patent anastomosis on a healthy duct with a rich blood supply, resulting in a low risk of bile leakage and long-term patency [17,18]. Current endoscopic and radiologic procedural developments increasingly offer minimally invasive techniques [26,27]. By decreasing or eliminating the bile duct to duodenum pressure gradient, endoscopic sphincterotomy and stenting enables a preferential transpapillary bile flow to dry out the leak when stricture occurs with an extrahepatic bile duct continuity still present. However, for major BDI or recurrent biliary stricture, these procedures are not indicated or are associated with high failure rates [28]. We believe that patients with major BDI or recurrent biliary strictures need to be referred directly to HBP teams with high expertise in biliary reconstruction to obtain the best chance of a good outcome.

Recurrent biliary stricture is a well-known complication of BDI repair, occurring mostly within 2 years follow-up, but sometimes after several years. Many authors even recommend at least 10 or even 20 years follow-up before concluding to a successful outcome post-BDI repair. Recurrent biliary stricture rates after secondary repair range from 12% to 30% in the current literature [13,14,23]. If undetected and/or untreated, biliary strictures can lead to chronic liver disease (requiring liver transplantation) or death [29]. In the present study, 3 referred BDI patients had secondary biliary cirrhosis, 1 of whom died from hepatic failure after hepaticojejunostomy. The recurrent biliary stricture rate post-BDI repair in referred patients was 9.6%, after 54 months median follow-up, one patient even developed a stricture after 19 years. Our results are thus similar to Johns Hopkins' long-term results, biliary strictures re-occurring in 9.2% patients, 1–86 months following biliary repair [30]. A very long-term follow-up after surgical biliary reconstruction for major BDI is therefore essential, including systematically laboratory test (with liver function parameters) and imaging by magnetic resonance cholangiography during the first 10 years, then every 2 years, in order to detect secondary biliary strictures.

The present study carries a number of limitations, including its retrospective design and extensive study period. On one hand, although biliary repair had a similar surgical management philosophy 30 years ago with respect to primary biliary suture, hepaticojejunostomy or Hepp-Couinaud's procedural techniques, there has been much progress not only in preoperative and postoperative multidisciplinary management but also in surgical materials and techniques over time, particularly in managing complications both radiologically and/or endoscopically. On the other hand, this long study period enabled late recurrent biliary strictures to be detected over a very long-term follow-up period. Another limitation was the lack of sufficient clinical or initial operative records for some referred patients, particularly those operated before 1990. Finally, we could not identify prognostic factors of poor outcome by logistic regression given the small numbers of biliary strictures.

Conclusion

Primary or secondary repair of cholecystectomy-related BDI is safe and effective in a tertiary HBP center. Long-term follow-up is recommended in view of the reported occurrence of late biliary strictures that may lead to chronic liver disease.

BDI can also occur in expert academic teaching centers, especially in difficult cases, but as shown by the present series, those that did occur at our center could mostly be detected intraoperatively thanks to a routine policy of IOC, and immediately be repaired resulting in a satisfactory outcome.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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