Original Article

Management of Laparoscopic Cholecystectomy-Related Bile Duct Injuries: A Tertiary Center Experience

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Abstract

Background: Laparoscopic cholecystectomy (LC)-related bile duct injuries remains a challenging issue with major implications for patient's outcome.

Methods: Between January 2008 and December 2012, we retrospectively analyzed the management and treatment outcomes of 90 patients with bile duct injury following LC.

Results: Forty-seven patients (52.2%) were treated surgically while the remaining 43 patients (47.8%) underwent non-surgical intervention. Injuries of Strasberg Type A and C were significantly more frequent in the non-surgical intervention group ($P = 0.016$, $P = 0.044$) whereas Type E2 was more frequent in the definitive surgery group ($P < 0.001$). The success rate of non-surgical intervention decreased as the waiting time increased whereas the success of definitive surgery was not time-dependent ($P = 0.048$). Initial jaundice (direct biluribin >1.3 gr/dL) significantly reduced the success rate of non-surgical interventions ($P = 0.017$). Presence of intraabdominal abscess significantly increased the complication rate after both definitive surgery and non-surgical interventions ($P = 0.04$, $P = 0.023$). Treatment success rates were similar in both surgery and non-surgical intervention groups according to the distribution of Strasberg injury types.

Conclusion: A multimodality approach is recommended in planning for patient-based treatment. Delayed referral reduces the success of nonsurgical interventions while it does not seem to significantly affect the success of surgical interventions when intraabdominal sepsis is under control.

Keywords: Bile duct injury, bile leak, bile duct stricture, Hepp-Couinaud hepaticojejunostomy

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Introduction

Laparoscopic cholecystectomy (LC) is the gold standard for treatment of symptomatic gallbladder disease.[1,2] However, bile duct injuries (BDIs) are more common after LC than open cholecystectomy (OC).[3] If BDIs occur, hazardous results may develope which affects patient's life quality and prolongs hospitalization period within a process that will sometimes lead to patient's death.[4,5]

The treatment approach for BDI is challenging because of patient-related factors such as degree of the injury and host response to injury or hospital conditions, including need for skill and adequate equipment; moreover, a universally accepted classification is not available yet to describe the type of injury.[6–8] Optimal treatment is advised in tertiary centers with a multimodality approach. However, most questions related to treatment success cannot be clearly answered, including ''which intervention algorithm has the best results?'', and ''What is the optimal timing for treatment?''.[9–15]

The aims of the present study are to evaluate the outcomes of adjunctive treatment modalities, surgical and non-surgical interventions on LC-related BDI and to determine factors affecting the success rate.

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Materials and Methods

Data for this study were retrieved from the database in Gastrointestinal Surgery Department at Turkiye Yuksek Ihtisas Teaching and Research Hospital. Between January 2008 and December 2012, we retrospectively analyzed the treatment outcomes of 132 patients with BDI following LC.

Patients treated with bilioenteric anastomosis at other centers, those referring with a diagnosis of benign bilier stricture (n = 7), and patients with missing data (n = 35) were excluded from the study. The study population consisted of 90 patients who either underwent surgical treatment or non-surgical intervention by endoscopic or percutaneous route.

Patients' symptoms and signs were defined as bile leak, jaundice, intraabdominal fluid collection (bilioma, abscess), and infection (peritonitis, cholangitis).

Liver enzymes, including alanine aminotransferase (ALT), aspartate aminotransferase (AST), gamma-glutamyl transferase (GGT), alkaline phosphatase (ALP) and bilirubin (Brb) levels were studied at pre-operative and post-operative period. All patients underwent preoperative abdominal ultrasonography (US) and chest radiography. All patients with intraabdominal collection were referred to interventional radiology for percutaneous drainage and patients with ongoing leakage were also referred to gastroenterology department for endoscopic evaluation. Antibiotic therapy was adjusted if cultures of drained material were positive. Investigation of possible vascular injuries associated with BDI is not a routine practice at our clinic unless clinical, radiological and

laboratory abnormalities are present.

The injuries and levels of the strictures were classified according to the Strasberg and Bismuth classifications after complete colangiographic images obtained by endoscopic retrograde cholangiopancreatograpghy (ERCP), magnetic resonance colangiopancreatography (MRCP) or percutaneous transhepatic cholangiography (PTC).[15] The time period from the first recognation of BDI to therapeutic interventions was defined as early (≤10 days), intermediate (11-44 days) or late (≥45 days).

Non-surgical interventions

Patients with BDI were initially evaluated by complete cholangiography. In the presence of Strasberg Type A injuries, a nasobiliary drainage catheter (NBD) was inserted. The NBD was removed or replaced with 10F biliary stent in the first week. These patients were followed up with repeated ERCPs and the stent was removed if leaking stopped.

Patients with aberrant BDIs (Strasberg injury Type B or C) were externally drained and complete cholangiography was obtained; then, a decision was made for surgery or the wait-and-see approach.

Although stenting is a more accepted treatment than NBD, we initially use NBD in Strasberg Type D and E with cholangitis because it shortens the recovery time with the help of a higher bilioatmospheric gradient than bilioduodenal gradient.[16] After cholangitis subsided, these patients were followed up with 2 or 3 additional stents if stricture existed. In the presence of a proximal stricture, a guidewire was inserted by PTC and the stricture was stented via this guide. Pneumotic dilatation was also applied for both ERCP and PTC procedures if needed.

For patients with complete bile duct obstruction or in cases where stenting was technically impossible, external drainage with PTC was performed and these patients were prepared for surgery.

All patients were followed at 3-month intervals unless the stents were plugged or dislocated. Removal of the stents within 12 months was accepted as successful treatment. The criteria for stent removal were improvement of clinical signs, liver enzymes and cholangiographic images.

Surgical interventions

Patients with bile peritonitis were explored in emergency circumstances. On the other hand, patients with jaundice, cholangitis or external bile fistula underwent elective surgery after diagnostic procedures had been completed and hemodynamic stability had been achieved.

The type of surgical procedure depended on the type and level of the injury, the length of the stricture as well as the patient's condition. Patients with Strasberg Type C injury underwent hepaticojejunostomy. If the choledochal tissue defect was less than one-third of the circumference of the duct (Strasberg Type D), primary repair with insertion of a T-tube catheter was performed. A biliary stent was inserted by ERCP simultaneously while removing the T-tube.

Injuries located more proximally and patients with a choledocal tissue defect more than one-third were treated with Roux-en-Y hepaticojejnustomy or Hepp-Couinaud hepaticojejunostomy. If placed preoperatively, percutaneous transhepatic drainage catheters were removed after normalization of clinical signs and cholangiographic images.

After discharge, all patients were checked on the 10th day and third month, and were further followed at 3-month intervals up to 12 months. Surgical therapy was accepted as successful after patient's convalesance was confirmed by radiologic images and normal or slightly elevated Brb, ALP and GGT levels. Surgical therapy was declared as unsuccessful in patients who had more than 2 attacks of cholangitis per year or those having more than a two-fold increase in liver enzymes with the requirement for additional surgical or radiological interventions.

Statiscal Analysis

Data was analyzed using SPSS for Windows, version 11.5 (SPSS Inc., Chicago, IL, United States). The Kolmogorov-Smirnov test was used to determine the normal distribution of continuous variables. Descriptive statistics for continuous variables were shown as mean ± standard deviation or median (min-max), where applicable. The mean differences between groups were compared with unpaired t-test; the Mann-Whitney U test was applied for comparisons of non-normally distributed data. Categorical data were expressed as number of cases and percentages. To compare categorical variables in 2 × 2 contingency tables, the Fisher's exact test was used if one or more of the cells had an expected frequency of 5 or less; otherwise, Pearson's Chi-square test was performed. A P value less than 0.05 was considered statistically significant.

Results

Ninety patients with BDI following LC were retrospectively analyzed. Of these, 80 patients (89%) underwent LC in other centers, whereas 10 patients (11%) were treated in our clinic. Twenty-five patients (27.7%) underwent LC for acute cholecystitis and 65 patients (72.3%) for symptomatic gallbladder disease. Surgery was required in 47 (52.2%) patients while the remaining 43 patients (47.8%) underwent non-surgical intervention.

The patients' characteristics and demographic data are listed in Table 1. No significant difference was found between the groups in terms of distributions of age, gender, BMI, initial surgery indication, referral period, treatment modalities after BDI in other centers, symptoms and signs at initial visit in our clinic, or the treatment success rate ($P > 0.05$). However, intrahepatic biliary dilatation was significantly more frequent in the surgery group than the non-surgical intervention group ($P = 0.032$). Strasberg Type A and C injuries were more often treated with non-surgical intervention ($P = 0.016$, $P = 0.044$) whereas Type E2 injuries were treated more often with surgery ($P < 0.001$). Although the type of injury is the main determinant of treatment type, non-surgical interventions in our study were significantly much more frequently performed in the early and intermediate time periods whereas surgery was chosen in the late periods ($P < 0.001$). The hospitalization period was significantly shorter in the non-surgical intervention group ($P < 0.001$).

Interventions performed in other centers are listed in Table 2. Abdominal exploration with insertion of a T-tube drainage catheter was the most frequently performed surgical procedure ($P = 0.017$).

The waiting time from initial surgery to definitive intervention significantly affected the success rate in patients who underwent non-surgical intervention. The success rate of non-surgical interventions decreased as the waiting time increased ($P = 0.048$). However, the success rate of surgery was not time-dependent (P

Table 1. Patients' characteristics and demographic data.

Variables	Non-operative (n = 43)	Surgery (n = 47)	*P*-Value
Age	47.09±14.9	45.74±14.6	0.667
Age distribution			0.869
<65	37 (86.0%)	41 (87.2%)	
≥65	6 (14.0%)	6 (12.8%)	
Gender			0.799
Male	12 (27.9%)	12 (25.5%)	
Female	31 (72.1%)	35 (74.5%)	
BMI			0.574
Normal weight	13 (31.3%)	25 (54.2%)	
Over weight + obese	30 (69.7%)	22 (45.8%)	
Initial Surgery			0.711
Emergency Cholecystectomy*	12 (66.7%)	13 (76.5%)	
Intrahepatic biliary dilatation	20/33 (60.6%)	27/32 (84.4%)	**0.032**
Referral period	22 (0-210)	45 (0-365)	0.089
Treatment intervention later than 10 days	24 (58.5%)	31 (66.0%)	0.473
Postoperative treatment in foreign center			
Surgery + drainage	5 (11.6%)	6 (12.7%)	> 0.9
T tube	11 (25.6%)	7 (14.9%)	0.205
Hepatostomy	1 (2.3%)	2 (4.3%)	> 0.9
Primary repair	1 (2.3%)	1 (2.1%)	> 0.9
Symptoms and signs at initial visit			
Biliary fistula	28 (65.1%)	24 (51.1%)	0.178
Jaundice	20 (46.5%)	35 (74.4%)	0.527
Fluid collection	16 (37.2%)	15 (31.9%)	0.598
Cholangitis	9 (20.9%)	12 (25.5%)	0.606
Abscess	2 (4.7%)	7 (14.9%)	0.161
Strasberg type injury			
A	12 (27.9%)	4 (8.5%)	**0.016**
B	0 (0%)	1 (2.1%)	> 0.9
C	8 (18.6%)	2 (4.3%)	**0.044**
D	4 (9.3%)	4 (8.5%)	> 0.9
E1	5 (11.6%)	8 (17.0%)	0.467
E2	6 (14.0%)	22 (46.8%)	**<0.001**
E3	8 (18.6%)	3 (6.4%)	0.077
E4	0 (0%)	3 (6.4%)	0.243
Period from injury to definitive treatment			**<0.001**
Early	13 (30.2%)	5 (10.6%)	
Intermediate	23 (53.5%)	14 (29.8%)	
Late	7 (16.3%)	28 (59.6%)	
Hospitalization period	9 (1-26)	17,5 (6-63)	**<0.001**
Complication rate	7 (16.3%)	22 (46.8%)	**0.002**
Treatment success rate	35 (81.4%)	40 (88.1%)	0.637

Table 2. Initial treatment interventions in other centers.

Variables	Surgery			Non-operative		
	Complications			Complications		
	No (*n* = 25)	Yes (*n* = 22)	*P*	No (*n* = 36)	Yes (*n* = 7)	*P*
Exploration+Drainage	0 (0%)	5 (22.7%)	**0.017**	4 (11.1%)	1 (14.3%)	> 0.9
ERCP-PTC	3 (12%)	2 (9%)	> 0.9	2 (5.6%)	2 (28.6%)	0.118
Hepatostomy	1 (4%)	1 (4.5%)	> 0.9	1 (2.8%)	0 (0%)	> 0.9
Primary repair	1 (16%)	0 (0%)	> 0.9	1 (2.8%)	0 (0%)	> 0.9
T tube drainage	4 (16%)	3(13.6%)	> 0.9	9 (25%)	2 (28.6%)	> 0.9
Total	**9 (36%)**	**11 (49.8%)**	**0.202**	**17 (47.3%)**	**5 (71.4%)**	**0.412**

ERCP = endoscopic-retrograd-pancreato-graphy, PTC = percutaneous transhepatic cholangiography.

Table 3. The waiting time from the initial surgery to definitive intervention.

	Non-operative		Surgery	
	*n**	Success rate (%)	*n**	Success rate (%)
Early (≤ 10 day)	13/0	100	100	5/0
Intermediate (10 < day ≤45)	23/5	79.3	79	14/3
Late (>45 day)	7/3	57	86	28/4
	$P = 0.048$		$P > 0.05$	
*Total number of patients / the number treatment failures				

> 0.05) (Table 3).

All patients underwent US. Abdominal computerized tomography (CT) was performed in 43 patients (47%) and MRCP in 29 patients (32%). ERCP was performed in 32 patients of the surgery group and 41 patients in the non-surgical intervention group. The rendezvous technique was used in five ERCPs. Bile duct stone was extracted by ERCP in two patients (4%) in the surgery group and in four patients (9%) in the non-surgical intervention group. PTC was performed in 26 patients (29%).

In the non-surgical intervention group, a total of 142 ERCP sessions were performed. During ERCPs, stent placement was performed in 28 patients, NBD catheter insertion in 6 patients, sphincterotomy in 5 patients, and dilatation in 2 patients, respectively. Two patients underwent only PTC and nine patients had additional percutaneous drainage. A significant negative correlation was found between treatment success and elongation of the treatment period with increase in the number of used stents. Having three or more stents within 12 months reduced the non-surgical treatment success rate ($P = 0.003$). No treatment failure was observed in patients whose stents were removed before 3 months. Complications developed in seven patients (16.2%). Of these, cholangitis occurred in three patients, subhepatic fluid collection and pleural effusion in two patients, pancreatitis in one patient, and hemorrhage in one patient. Spontaneous bilioenteric fistula occurred in three patients. No mortality occurred and the success rate of non-surgical interventions was 81%. Subsequent surgery after non-surgical treatment failure was performed in three patients due to recurrent cholangitis and serious stricture: Roux-en-Y hepaticojejunostomy was performed for two patients and Hepp-Coinaud hepaticojejunostomy for one patient.

In the surgery group, Hepp-Couinaud hepaticojejunostomy (18 patients, 38.2%) was the most frequently performed elective operation followed by Roux-en-Y hepaticojejunostomy (17 patients, 36.2%) and T-tube drainage (6 patients, 12.7%). Urgent surgery was performed for five patients with bile peritonitis and one patient with intraabdominal hemorrhage. Primary repair and drainage was the type of the prefered surgery. Complications developed in 20 patients (42.5%). Of these, wound infection was the most commonly detected complication (n = 9, 18%). Temporary bile leak occurred in four patients (8%), ileus in two patients (4%), and pneumonia in two patients (4%). Re-exploration was required in two patients due to evisceration and in one patient due to hemorrhage. The success rate in the surgery group was 88.1%. Two patients (4%) died after urgent surgery, one from intraabdominal sepsis and the otherfrom Candida sepsis. Baloon dilatation was used in five patients in whom surgical interventions failed and no further interventions were required in the follow-up period of 12 months.

The success rate of both surgery and non-surgical interventions were not significantly affected by age, gender, BMI or ASA scores ($P > 0.05$) (Table 4).

The patients' symptoms and signs at admission before treatment included biliary fistula, abscess, cholangitis, jaundice and fluid collection. None of these had a significant effect on the success rate of surgery ($P > 0.05$). However, jaundice significantly reduced the success rate of non-surgical interventions ($P = 0.017$). Presence of intraabdominal abscess significantly increased the complication rate after both surgery and non-surgical interventions ($P = 0.04$, $P = 0.023$), (Table 5).

Vasculer injuries were detected in three patients: one aberrant right hepatic artery from superior mesenteric artery, one from right hepatic artery during LC and one after PTC. The first two

Table 4. The effect of patients' characteristics on treatment success after definitive surgery and non-surgical interventions.

	Surgery			Non-operative		
Variables	**Successful (*n* = 40)**	**Failure (*n* = 7)**	***P* value**	**successful (*n* = 35)**	**Failure (n = 8)**	***P* value**
Age	45.4±14.1	47.9±18.5	0.684	47.2±15.3	46.6±14.2	>0.9
<65	36 (90.0%)	5 (71.4%)		31 (88.6%)	6 (75.0%)	
≥65	4 (10.0%)	2 (28.6%)		4 (11.4%)	2 (25.0%)	
Gender			0.659			> 0.9
Male	11 (27.5%)	1 (14.3%)		10 (28.6%)	2 (25.0%)	
Female	29 (72.5%)	6 (85.7%)		25 (71.4%)	6 (75.0%)	
BMI	24.6 ± 3.2	26.7 ± 2.9	0.240	26.4 ± 3.4	26.2 ± 5.6	0.871
ASA score	2.12 ± 0.78	2.42 ± 0.97	0.421	-	-	

Table 5. The effect of symptoms and signs on complications on admission.

Surgery	**No (*n* = 25)**	**Yes (*n* = 22)**	***P*-Value**
Biliary fistula	14 (56.0%)	10 (45.5%)	0.471
Abscess	1 (4.0%)	6 (27.3%)	**0.040**
Cholangitis	5 (20.0%)	7 (31.8%)	0.354
Jaundice	15 (60.0%)	10 (45.5%)	0.319
Fluid collection	6 (24.0%)	9 (40.9%)	0.215
Non-operative	**No (*n* = 36)**	**Yes (*n* = 7)**	***P*-Value**
Biliary fistula	24 (66.7%)	4 (57.1%)	0.680
Abscess	0 (0%)	2 (28.6%)	**0.023**
Cholangitis	6 (16.7%)	3 (42.9%)	0.147
Jaundice	18 (50.0%)	2 (28.6%)	0.420
Fluid collection	12 (33.3%)	4 (57.1%)	0.394

Table 6. Comparison of the groups according to the Strasberg classification.

Strasberg	**Surgery**			**Non-operative**		
Injury type	**Successful (*n* = 40)**	**Failure (*n* = 7)**	***P*-Value**	**Successful (*n* = 35)**	**Failure (*n* = 8)**	***P*-Value**
A	3 (7.5%)	1 (14.3%)	0.488	12 (34.3%)	0 (0%)	0.082
B	1 (2.5%)	0 (0%)	> 0.9	-	-	-
C	2 (5.0%)	0 (0%)	> 0.9	7 (20.0%)	1 (12.5%)	> 0.9
D	4 (10.0%)	0 (0%)	> 0.9	3 (8.6%)	1 (12.5%)	> 0.9
E1	6 (15.0%)	2 (28.6%)	0.585	3 (8.6%)	2 (25.0%)	0.228
E2	19 (47.5%)	3 (42.9%)	> 0.9	4 (11.4%)	2 (25.0%)	0.308
E3	2 (5.0%)	1 (14.3%)	0.391	6 (17.1%)	2 (25.0%)	0.629
E4	3 (7.5%)	0 (0%)	> 0.9	-	-	-

cases were treated surgically and the latter was treated with embolization.

Strasberg Type E was the most frequently occurring injury type (55 patients, 61.1%) followed by Type A (16 patients, 17.7%), Type C (10 patients, 11.1%), Type D (8 patients, 8%), and Type B (1 patient, 1.1%), respectively. The success rates of surgery and non-surgical intervention groups were not significantly different based on the distribution of injury types ($P > 0.05$) (Table 6).

Discussion

The incidence of BDI following LC has been reported as 0.5%–0.8%. Several studies have shown that LC-related BDIs are often proximally located and more complex than OCs.[3,16,17] Strasberg type A injuries are the most common BDI which is reported from 54% up to 70%, followed by type D and E injuries ranging between 11% and 28.6%.[17,18] In contrast to other studies, 61.1% cases of the present study had type E injury. This is probably related to the resolution of minor injuries by conservative approach or simultaneous repair of discerned injuries during the initial surgery in referring hospitals. Thus, patients with major injuries are usually referred to our tertiary center clinic.

In the literature, only 10% to 30% of BDIs are realized simultaneously during LC.[3] Kaman *et al*.[19] reported simultaneous realization of Strasberg type E injuries as 52%. Simultaneous injury realization was 16.6% in the present study, including patients referred from other centers. The detection of Strasberg type D and E injuries during the operation rose up to 75% in our study. This can be explained by the fact that by two surgeons perform the operations in our center, and in all cases when the anatomy cannot be clearly defined, a third surgeon is also invited.

There is a consensus for immediate repair of BDI detected during the primary surgery; however, no consensus exists about the timing of surgery in cases where injury is detected days or weeks later. The inflammation is not obvious during the first 72 hours after BDI. The undrained bile collections become infected after 9–10 days. There are different success rates across treatments performed before six weeks and after six weeks that accompany relatively dilated bile ducts, subsided infection and inflammation and ischemia before repair. On the other hand, some authors claimed that early referral, eradication of intraabdominal infection, use of correct surgical technique by experienced hepatobiliary surgeons and obtaining complete cholangiography are more important than timing of the surgery in terms of optimal results. In the present study, the time interval from injury to surgical treatment did not significantly affect the rate of treatment success.[11,20–23] Indeed, the treatment success with non-surgical interventions was 100% in patients who were managed during the first 10 days while the success rate decreased to 57% in those treated later. Delay in the treatment with concomitant hyperbilirubinemia is strongly associated with development of fibrosis and stricture formation in the inflamed and infected area which adversely affect the treatment success of non-surgical interventions.

In the literature, several studies have shown that bilioenteric anastomosis made by inexperienced surgeons with any initiative out of the tertiary centers would reduce the success and increase the complication rates.[20,24] Dageford *et al*.[21] compared early surgical

attempts with those in the late period in terms of treatment cost and quality of life. They observed that the results were optimized when surgery was performed in the early period by an experienced hepatobiliary surgeon. The results of the present study indicate that repair of a proximally located injury during the initial surgery by an inexperienced hand would not only complicate future surgical attempts but also significantly increase complication rates after the second surgical intervention ($P = 0.017$). Hence, when the injury is spotted during LC without access to a experienced surgeon or equipment, referring the patient to a tertiary center after placing a drainage catheter seems to be more efficacious.

The routince practice in our clinic for Strasberg type E1 and E3 injuries is to prefer Hepp-Coinad hepaticojejunostomy because of the rich vascular supply of this area. On the other hand, T-tube drainage is preferred in Strasberg type D injuries (even at the risk of stricture formation) which provides the eligibility of further surgical attempts on proximal locations when necessary. We always consider endoscopic stenting just after removal of the T-tube to avoid the risk of leakage and stricture formation. Our success rate after surgery is 88.1% which is consistent with the literature.[19,25,26]

Non-operative approach, including endoscopic or percutaneous interventions, has been reported successful for management of short segment strictures, and in the absence of complete biliary obstruction or injuries of the common bile duct involving less than 50% of lumen.[27] Injuries located more proximally, duration of the treatment and formation of stricture following removal of the stent are risk factors which reduce the success of optimal treatment.[28-30] In the present study, the success rate of non-surgical interventions was 81%. The success rate rose up to 100% in the treatment of cystic duct injuries or leaks from ducts of Luschka whereas it diminished progressively in Strasberg D and E injuries. The median duration of stents was 16 months. Remarkably, presence of jaundice within stricture formation in the absence of bile leakage had a significant negative impact on the treatment success ($P = 0.04$).

One of the practices in our clinic is to insert multiple stents for proximally located injuries due to the risk of development of a stricture. In the present study, six patients had multiple stents (≥3 stents) which remained for more than 12 months. It should be considered that non-surgical treatment time is prolonged in the presence of proximal lesions with stricture formation.

The complication rates in the present study after surgical and non-surgical interventions were 46.8% and 16.2%, respectively. Surgical repair attempt during initial surgery significantly increased the complication rate in the surgery group. Presence of jaundice and cholangitis on admission significantly increased complication rates after non-surgical interventions. Presence of intraabdominal abscess significantly increased the complication rates in both surgery and non-surgical intervention groups ($P = 0.04$ and $P = 0.023$, respectively).

The mortality rate after BDI was reported by Warren *et al*.[31] as 8.4%. In a review by Flum *et al*.,[32] the mortality rate was calculated as 2.7%. It has been proven that treatment in tertiary centers reduces the mortality rates. The perioperative mortality was 4% (two patients) in the present study.

In conclusion, the choice of optimal treatment approach for BDI is crucial as it entails not only vital and progressive effects on patient's quality of life, but also affects the necessity of subsequent treatment interventions. In addition to the type of injury, differences between the individuals in terms of anatomical variations and host response to injury make it difficult to establish standard treatment protocols and algorithms. A multidisciplinary team consisting of experienced hepatobiliary surgeons, interventional radiologists and gastroenterologists is recommended in planning for patient-based treatment. Delayed referral with presence of stricture formation reduces the success of non-operative interventions.

Compliance with ethical standards

All procedures performed in the present study were in accordance with the ethical standards of the institutional and/or national research committee and the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent

Informed consent was obtained from all individual participants included in the study.

Conflict of Interest

The authors declare that they have no conflict of interest.

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