Real-Life Situation Of Bile Duct Injury Management: Challenges And Lessons From A Tertiary Care Center

Triyanta Y. Pramana, Apriliana Adhyaksari**,***, See Young Lee*****, Thawee Ratanachu-ek******, Stefanus Satrio Ranty**, Ari Prasetyo**, Aritantri Darmayani*, Didik Prasetyo*, Anung Notonugroho*****

*Division of Gastroenterohepatology Internal Medicine Department, Faculty of Medicine Sebelas Maret University Dr. Moewardi Hospital, Surakarta

**Subspecialist Program Division of Gastroenterohepatology Internal Medicine Department, Faculty of Medicine Sebelas Maret University Dr. Moewardi Hospital, Surakarta

***Internal Medicine Department, Faculty of Medicine Pembangunan Nasional Veteran University, Jakarta

****Division of Digestive Surgery, Department of Surgery, Faculty of Medicine Sebelas Maret University Dr. Moewardi Hospital, Surakarta

*****Department of Internal Medicine, Institute of Gastroenterology, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, Republic of Korea

******Rajavithi Digestive Endoscopy Center, Department of Surgery Rajavithi Hospital, Bangkok, Thailand

Corresponding author:

Triyanta Yuli Pramana. Postal address: Surakarta, Indonesia 57126. E-mail: typramana@gmail.com. Telephone: +62 81338327327

ABSTRACT

Background: *Bile duct injury (BDI) is a serious complication of cholecystectomy, particularly with the widespread adoption of laparoscopic cholecystectomy (LC). Currently, a wide spectrum of multidisciplinary interventions with different degrees of invasiveness is indicated for BDI management. This study evaluates real-life clinical experiences in managing post-cholecystectomy BDIs in Central Java, Indonesia. We aim to discuss the prevention of BDI further and find out the most effective management and timing of interventions for BDI based on these analyses.*

Methods: *Twenty-seven cases with iatrogenic BDI following cholecystectomy were classified according to BDI Strasberg classification, repair procedures, mortality and success rate procedures, onset of BDI, and timing of repair procedures. The correlation analyses were performed using the Contingency Coefficient Correlation Test.*

Results: *Of the 27 patients, BDIs were detected in 33.3% of patients within two weeks of surgery. Major BDIs (Strasberg E) often required biliodigestive surgery, with variable outcomes. The overall mortality rate was 29.6%, mainly due to biliary sepsis. ERCP success was significantly associated with less severe BDI (p=0.018). This study stated that the type of previous cholecystectomy, timing of BDI diagnosis, and duration of BDI to repair procedures did not statistically influence mortality (p=0.822, p=0.551, p=0.958, respectively).*

Conclusion: *Prevention of BDI is paramount, emphasizing surgical training, careful patient selection, and the critical view of safety technique. Early detection, multidisciplinary management tailored to the injury's severity improve outcomes. While minimally invasive approaches are preferred for minor BDIs, major injuries necessitate surgical intervention by experienced hepatobiliary surgeons.*

Keywords : *Bile duct injury (BDI), Percutaneous Transhepatic Biliary Drainage (PTBD), Endoscopic retrograde cholangiopancreatography (ERCP), Billiodigestive surgery, Strasberg Classification*

ABSTRAK

Latar Belakang: *Cedera saluran empedu (BDI) adalah komplikasi serius dari kolesistektomi, terutama yang menggunakan prosedur kolesistektomi laparoskopi (LC). Saat ini, intervensi multidisiplin yang luas dengan tingkat invasif yang berbeda telah tersedia untuk manajemen BDI. Penelitian ini mengevaluasi pengalaman klinis nyata dalam penanganan BDI pasca-kolesistektomi di Jawa Tengah, Indonesia. Kami bertujuan untuk membahas pencegahan BDI lebih lanjut dan mengetahui manajemen dan waktu intervensi yang paling efektif untuk BDI berdasarkan analisis ini.*

Metode: *27 kasus BDI iatrogenik pasca kolesistektomi diklasifikasikan menurut klasifikasi BDI Strasberg, prosedur intervensi, tingkat mortalitas dan tingkat keberhasilan, waktu terdiagnosis BDI, dan waktu dilakukannya intervensi. Analisis korelasi diuji menggunakan Uji Korelasi Koefisien Kontingensi.*

Hasil: *Dari 27 pasien, BDI terdeteksi pada 33,3% pasien dalam waktu dua minggu setelah operasi. BDI mayor (Strasberg E) sering membutuhkan operasi biliodigestif, dengan hasil yang bervariasi. Tingkat kematian keseluruhan adalah 29,6%, terutama karena sepsis bilier. Keberhasilan ERCP secara signifikan dikaitkan dengan BDI minor (p=0,018). Penelitian ini menunjukkan bahwa jenis tindakan kolesistektomi sebelumnya, onset BDI, dan waktu dilakukannya intervensi BDI secara statistik tidak mempengaruhi mortalitas (masing-masing p=0,822, p=0,551, p=0,958).*

Kesimpulan: *Pencegahan BDI adalah yang terpenting, menekankan pada pelatihan tindakan bedah, pemilihan pasien yang cermat, dan pandangan kritis tentang teknik keselamatan. Deteksi dini, manajemen multidisiplin yang disesuaikan dengan tingkat keparahan cedera dapat meningkatkan keluaran klinis yang baik. Sementara pendekatan minimal invasif lebih disukai untuk BDI minor, cedera mayor memerlukan intervensi bedah oleh ahli bedah hepatobilier yang berpengalaman.*

Keywords: *Cedera saluran empedu, Drainase Bilier Transhepatik Perkutan, Endoskopik Retrograd Kolangiopankreatografi, Operasi biliodigestif, Klasifikasi Strasberg*

INTRODUCTION

Gallbladder disease is a common health problem in developed countries and the most common intra-abdominal disease, affecting 10-15% of the world's adult population, and in developing countries such as Indonesia, an estimated 10-15% of the adult population suffers from gallstones .[1-3] Cholelithiasis is a gallstone formed from cholesterol, bilirubin, or bile fluid. Asymptomatic gallstones are usually found incidentally and 1% to 2% of cases become symptomatic or experience complications within 1 year. However, within ±15 years, these asymptomatic gallstones can cause symptoms in about 20% of cases if not followed up regularly and may progress to more serious disease complications, and cholecystectomy is the most common elective abdominal surgery chosen by clinicians, with the vast majority of which are laparoscopic (LC).[1-5] However, the downside that must be considered from the implementation of the procedure by surgeons who do not have sufficient training in LC is bile duct injury (BDI), which is currently increasing. [3-5] The cumulative incidence of BDI after cholecystectomy in the literature is around 0.1% to 3%.[3-20] LC has a two-fold higher risk of bile duct injury, and its frequency can be further increased in acute gallbladder (GB) inflammation. Meanwhile, bile duct injury after biliary endoscopy, interventional radiology, and liver biopsy has been reported incidentally.[4] Bile duct injury (BDI) is a feared and potentially life-threatening complication post-cholecystectomy with mild to severe clinical manifestations, increasing morbidity and mortality rates, and reducing long-term quality of life.[6,9–20] Ultimately, understanding the mechanism of BDI in deep-dyed, have knowledge about the critical view of safety, and appropriate patient selection is the fundamental element in preventing the occurrence of BDI.[6,9] Currently, a wide spectrum of multidisciplinary interventions with different degrees of invasiveness is indicated for BDI management. This can be achieved through close cooperation between gastroenterologists, interventional radiologists, and digestive surgeons. Therefore, in this study, we discuss and review the baseline data of patients, analyze the causes of BDI, the timing of detection of BDI, the actual interventions and management in our hospital, and analyze the outcomes. We aim to further discuss the prevention of BDI and find out the most effective management and timing of interventions for BDI, according to the severity level based on these analyses.

METHODS

Twenty-seven cases with iatrogenic BDI post cholecystectomy that happened in or were referred to Moewardi Regional General Hospital Surakarta, internal medicine or digestive surgical department from January 2023 to February 2025, and were analyzed retrospectively. We would like to thank our institute for giving ethical permission and allowing us to collect the data with number of ethical permission 8864/IV/HREC/2025.

Patients were classified based on the cholecystectomy procedure that had been performed (laparotomy or open cholecystectomy (OC) or Laparoscopic cholecystectomy (LC)), BDI Strasberg classification, the repair procedures or any interventions they received, their mortality and success rate procedures, onset of BDI and timing of repair procedures. Inclusion criteria in this study were adult patients, >18 years old, with BDI post cholecystectomy for biliary stone indications. Patients with malignancy were excluded.

In this study, the Strasberg classification was used to determine the BDI classification, as seen from the results of MRCP or abdominal MRI with contrast or cholangiography when performing ERCP, as shown in **Figure 1**. We further classified the type of BDI with major (Strassberg E) and minor (Strassberg A-D). The subject data of this study based on Strasberg classification is listed in **Table 1**.

Resolution of jaundice, sepsis, and cholangitis were defined as good outcomes and defined as a successful repair procedure. Worsening of sepsis, jaundice, and cholangitis and the presence of persistent leaks with or without drainage tubes or still having biliary strictures are interpreted as poor results or failed repair procedures. Statistical analysis was performed using SPSS Stata software version 26.0 (Stata Corp, College Station, Tex), with data expressed as percentages, means, and ranges. The correlation analyses were performed using the Contingency Coefficient Correlation Test with $p<0,005$ was statistically significant. This study has obtained permission from the ethics committee of Dr. Moewardi Hospital, Surakarta.

DIAGNOSIS

CLINICAL MANIFESTATIONS

Clinical manifestations are closely related to the indications for previous cholecystectomy and the type of BDI. This causes the clinical manifestations that appear to vary from mild symptoms to severe such as cholangitis with septic shock, which can lead patients to die within less than 48 hours of hospitalization, mostly due to biliary sepsis.

Most of our patients had complained of diffuse abdominal pain, abdominal distension, nausea, fever, and jaundice. In addition, bile collections intra-abdominal which are mostly subhepatic, peritonitis, leucocytosis, and mixed hyperbilirubinemia may be found in supporting examination. In this study, an obstructive type of BDI which is marked with obstructive patterns on liver function tests accompanied by jaundice was more common. Among these 27 patients, 9 (33.3%) were diagnosed with BDI less than 2 weeks after cholecystectomy and the remaining 18 were diagnosed with BDI more than 2 weeks after cholecystectomy (66.7%). None of them were diagnosed with BDI intraoperatively. BDI in all subjects was detected during post-operative procedures while they still complained of persistent abdominal pain and jaundice in the outpatient department.

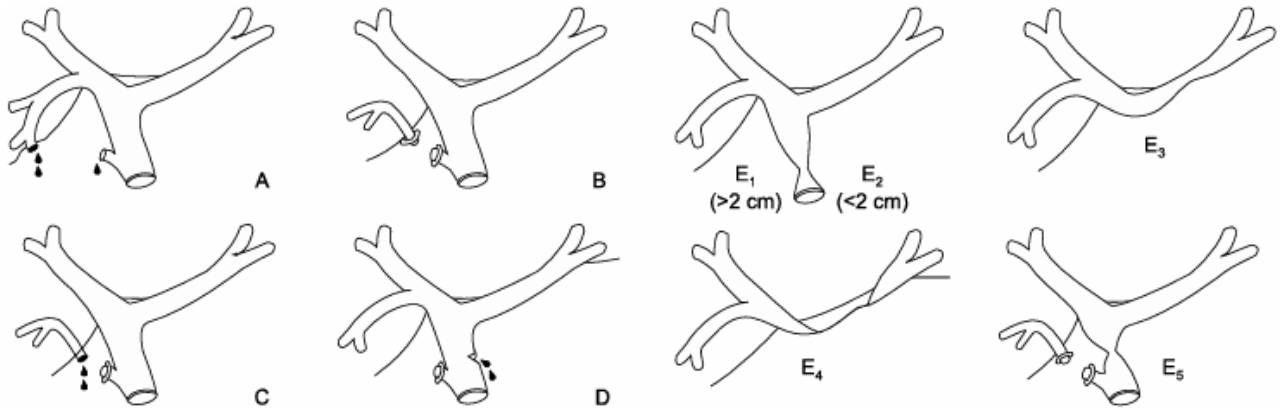

Figure 1. Strasberg classification.[8,13]

IMAGING MODALITIES

Imaging modalities included abdominal ultrasonography (USG), computed tomography (CT), endoscopic retrograde cholangiopancreatography (ERCP), transhepatic cholangiography percutaneous (PTC), Percutaneous Transhepatic Biliary Drainage (PTBD), magnetic resonance imaging (MRI) and magnetic resonance cholangiopancreatography (MRCP).

RESULTS

BASELINE CHARACTERISTICS

A retrospective review was conducted on patients diagnosed with bile duct injury (BDI) following cholecystectomy at our hospital between January 2023 and February 2025. The study protocol was approved by the Institutional Ethics Committee. All referred patients were evaluated by attending physicians from either the digestive surgery or gastroenterology departments, who independently determined the most appropriate therapeutic approach. No standardized clinical guideline for the management of post-cholecystectomy BDI is currently implemented in our institution, resulting in variability in treatment strategies based on the attending physician's specialty and clinical judgment.

This report includes only patients who developed BDI following cholecystectomy, performed by laparoscopy or laparotomy, regardless of the initial indication. A total of 27 patients were identified with BDI during the study period. Of these, 21 patients (77.78%) had undergone laparoscopic cholecystectomy, while 6 patients (22.22%) underwent open (laparotomy) cholecystectomy. Notably, 63% of the cases were referrals from other institutions, where the initial cholecystectomy had been performed.

GENDER

The majority of the subjects were female (19 patients; 70.4%), which aligns with previous studies indicating a higher prevalence of cholelithiasis and biliary tract stones among women.[1–2] All 27 patients (100%) included in this study were diagnosed with gallbladder or biliary stones as the primary indication for cholecystectomy. A summary of the baseline characteristics of the study population is presented in **Table 1.**

Table 1. Baseline Characteristic

Variable	(n, %)
Classification of Bile Duct Injuries	
A	8 (29,6)
B	1 (3,7)
D	7 (25,9)
E1	3 (11,1)
E2	5 (18,5)
E5	1 (3,7)
Unknown	2 (7,4)
Gender	
Female	19 (70.4)
Male	8 (29.6)
Age	46.93±15.20
Laparotomy Cholecystectomy	6 (22.2)
Laparoscopic Cholecystectomy	21 (77.8)
ERCP	
Not performed	4 (14.8)
Failed	12 (44.4)
Success	11 (40.7)
Biliodigestive Surgery	
Not performed	14 (51.9)
BDI or leakage still persists	9 (33.3)
Success surgery	4 (14.8)
Onset of BDI	
<2 weeks	9 (33.3)
≥2 weeks	18 (66.7)
Duration BDI to ERCP	
<1 week	11 (40.7)
≥1 week	12 (44.4)
ERCP was not performed	4 (14.8)
Outcome	
Clinical Improvement After Repair (with or without drainage tube)	19 (70.4)
Died	8 (29.6)

MANAGEMENT

All cases were managed using a range of tailored interventions, including intra-abdominal percutaneous drainage due to biloma formation, Percutaneous Transhepatic Biliary Drainage (PTBD), Endoscopic retrograde cholangiopancreatography (ERCP), Endoscopic ultrasound-guided biliary drainage (EUS-BD), and biliodigestive surgery. The types of procedures performed and their respective success rates are detailed in the **Table 2.** At our institution, a standardized protocol for bile duct injury (BDI) management has not yet been established; therefore, treatment decisions are made based on the clinical judgment and expertise of the attending specialists. Patients often required one or more procedures, either simultaneously or across multiple hospital admissions**.** In this study, BDI classification was based on the Strasberg system.[3-7] BDI was identified within two weeks post-cholecystectomy in 9 patients (33.3%), while the remaining 18 patients (66.7%) were diagnosed more than two weeks after surgery. The

timing of diagnosis significantly influenced prognosis and recovery. Not all patients underwent early primary repair; some required delayed primary repair, typically performed six weeks or more after the injury.

Table 2. Types of procedures performed and success rates

Procedures	Failed n (%)	Success n (%)
Intra-abdominal percutaneous drainage + PTBD + Biliodigestive surgery + ERCP + EUS-BD	1 (3,7)	0
Intra-abdominal percutaneous drainage + ERCP	0	1 (3,7)
Biliodigestive surgery only	0	2 (7,4)
Biliodigestive surgery + PTBD	0	1 (3,7)
Biliodigestive surgery + PTBD + ERCP	4 (14,8)	1 (3,7)
Biliodigestive surgery + ERCP	2 (7,4)	2 (7,4)
ERCP only	0	8 (29,6)
ERCP + PTBD	3 (11,1)	0
ERCP + PTBD + EUS-BD	0	1 (3,7)
No procedures was performed	1 (3,7)	0

Note :
All procedures are carried out sequentially as written
Patient died before all procedures were performed due to biliary sepsis
Patient died due to biliary sepsis or other causes or still having a BDI after the procedures performed
Percutaneous Transhepatic Biliary Drainage (PTBD), Endoscopic retrograde cholangiopancreatography (ERCP), and Endoscopic ultrasound-guided biliary drainage (EUS-BD).

The number of BDI cases referred to our hospital has shown a clear upward trend in recent years, with 2 to 3 new cases presenting each month for advanced management. Patients presenting with active sepsis and multi-organ dysfunction who remain hemodynamically stable are promptly treated, particularly with minimally invasive interventions, when feasible. However, in cases of septic shock accompanied by severe multi-organ failure, procedural intervention is strategically deferred until the patient's condition stabilizes, ensuring optimal safety and outcomes. A wide range of procedural combinations was employed in the management of bile duct injuries (BDI), reflecting the complexity and variability of clinical presentations. The most successful single intervention was endoscopic retrograde cholangiopancreatography (ERCP) alone, which accounted for 29.6% of successful outcomes, with no failures recorded in this group. This highlights the efficacy of ERCP as a minimally invasive first-line approach in select patients.

In contrast, more complex, multi-step interventions—such as the combination of biliodigestive surgery, percutaneous transhepatic biliary drainage (PTBD), and ERCP—showed lower success rates and higher failure rates, with the combination of biliodigestive surgery + PTBD + ERCP resulting in a 14.8% failure rate. These cases likely represent patients with more severe injuries or complications requiring escalation of care. Procedures involving EUS-BD, though performed less frequently, demonstrated potential value in specific settings, with one successful outcome recorded when combined with ERCP and PTBD. Notably, patients who underwent biliodigestive surgery alone achieved a 100% success rate (7.4%), suggesting that direct surgical repair remains an effective definitive treatment when appropriately indicated. Only one patient could not undergo any intervention due to rapid clinical deterioration from biliary sepsis, emphasizing the importance of timely diagnosis and management.

INTRAADBOMINAL PERCUTANEOUS DRAINAGE

In this study, we performed percutaneous drainage as initial therapy, especially in patients with biloma pockets greater than 5 cm. In 3 of the 27 subjects we performed this procedure, in which 2 of 3 subjects were Strasberg E2, while the remaining 1 subject was Strasberg A1. This percutaneous drainage procedure is not be reliable as a single definitive procedure, but must be followed by additional procedures. At our institution, this approach is most commonly followed by ERCP with biliary stent placement, which allows for targeted management of the biliary leak and facilitates timely resolution. This combined strategy minimizes the duration of external drainage, which is typically removed within 1 to 2 weeks once the biloma has resolved during observation.

ENDOSCOPIC RETROGRADE CHOLANGIOPANCREATOGRAPHY (ERCP)

Endoscopic Retrograde Cholangiopancreatography (ERCP) has emerged as a valuable therapeutic modality that is reshaping the approach to managing bile duct injury (BDI). ERCP is widely recognized for its high success rate, cost-effectiveness, and association with lower morbidity and mortality compared to surgical interventions. Nevertheless, surgical repair is still considered the gold standard for definitive management in complex or major BDI cases.[4,18,19]

In our study of 27 patients with BDI, 11 patients (40.7%) were successfully treated with ERCP and biliary plastic stent insertion, while 12 patients (44.4%) experienced ERCP failure. The remaining 4 patients (14.8%) did not undergo ERCP: 2 died within 48 hours of admission due to severe biliary sepsis, and 2 proceeded directly to biliodigestive surgery. Notably, 4 of the 12 ERCP failures had previously undergone

biliodigestive surgery, which significantly alters the anatomy of the biliary tree and limits the effectiveness of endoscopic intervention. The impact of biliary anatomy and injury severity, as classified by the Strasberg classification, was evident in our findings. ERCP was only successful in patients with minor BDI, specifically in those with Strasberg A (7 patients; 63.6%), B (1 patient; 9.1%), and D (3 patients; 27.3%) classifications. In contrast, ERCP failure was observed in patients with more severe injuries: Strasberg D (2 patients; 16.7%), E1 (3 patients; 25%), E2 (5 patients; 41.7%), E5 (1 patient; 8.3%), and in 1 unclassified case (8.3%), where the patient died before further diagnostic assessment could be completed.

Importantly, the correlation between ERCP success and Strasberg classification was statistically significant (p = 0.018), emphasizing the critical role of injury severity and anatomical considerations in guiding therapeutic decisions. Detailed outcomes by classification are presented in **Table 3.**

Table 3. ERCP Correlation Analysis Against Strasberg Class

Variable	ERCP			r	p
	Not Performed (n=4)	Failed (=12)	Success (n=11)		
	n (%)	n (%)	n (%)		
Strasberg Class				0.689	**0.018**
A	1 (25.0)	0 (0.0)	7 (63.6)		
B	0 (0.0)	0 (0.0)	1 (9.1)		
D	2 (50.0)	2 (16.7)	3 (27.3)		
E1	0 (0.0)	3 (25.0)	0 (0.0)		
E2	0 (0.0)	5 (41.7)	0 (0.0)		
E5	0 (0.0)	1 (8.3)	0 (0.0)		
unknown	1 (25.0)	1 (8.3)	0 (0.0)		

Correlation Test Description Contingency coefficient; significant at p<0.05

A previous study stated that ERCP was efficient in the management of 88.46% of BDI. There was no difference between early and late ERCP in the management of BDI. Furthermore, there were no further adverse events that occurred during the ERCP procedure.[10,18,19] In this study, we revealed that there were no significant differences in outcome between patients treated by early (first week) versus late (after the first week) ERCP (p=0.958). There were also no significant differences in outcomes between patients who underwent ERCP or underwent other procedures besides ERCP (p=0.145). There were no further adverse effects associated with ERCP management in this study. Some of the ERCP and PTBD procedures we have performed are attached as shown in **Figure 2.**

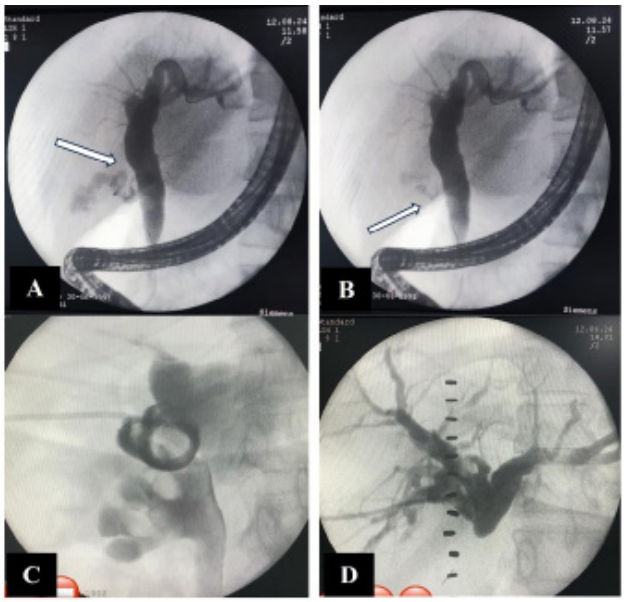

Figure 2 (A, B). Strasberg A. Biliary leakage at the cystic duct stump of cholecystectomy (white arrow). (C). Strasberg E5. With biliary leakage accompanied by the formation of cutaneous biliary fistula and severe secondary infection due to intra-abdominal biloma, induced formation of cutaneous-renal fistula. (D). Strasberg E2. Dilated Biliary duct due to common biliary duct ligation >2cm.

PERCUTANEOUS TRANSHEPATIC BILIARY DRAINAGE (PTBD)

Major BDIs are supposed to have a percutaneous transhepatic cholangiography with PTBD placement for biliary decompression and maintaining biliary flow.[11-13] PTBD is one of the most important additional procedures that must be performed on patients who failed ERCP, to achieve biliary decompression, or post-ERCP cholangitis. PTBD is also recommended in patients with hilar obstruction or cases that experience changes in biliary structure. The percutaneous approach in PTBD aims to facilitate biliary flow, thereby facilitating the healing process at the leakage site.[12] Unsuccessful ERCP has a failure rate of 5-20%, particularly in cases where patients have undergone BDI repair with biliodigestive surgery, especially using the technique of pancreaticoduodenectomy or with Roux-en-Y anastomosis, endoscopic access via ERCP is not possible. In such cases, PTBD can be an option for biliary drainage. PTBD can also be performed in patients who experience post-ERCP cholangitis.[11]

In this study, 11 out of 27 patients (40.7%) underwent percutaneous transhepatic biliary drainage (PTBD), with a failure rate of 18.2% (2 patients). All procedures were performed using a standardized ultrasound-guided technique, regardless of the presence or absence of bile leakage (8 patients with leakage; 3 without). The vast majority (10 of 11 patients) exhibited a dilated biliary system, consistent

with obstructive pathology, allowing for successful placement of an external drainage catheter into the biliary hilum. PTBD was primarily indicated in patients with major BDI, including Strasberg D (3 patients), E1 (1 patient; failed), E2 (4 patients), E5 (1 patient), and 1 unclassified case (failed). Only one patient with a minor BDI (Strasberg A) underwent PTBD—this patient had previously undergone biliodigestive surgery, which failed to resolve a persistent bile leak. This secondary leakage was suspected to be due to a new iatrogenic injury from the second surgery. Unfortunately, ERCP was not attempted prior to surgical intervention, and the patient later succumbed to biliary sepsis. The other failed PTBD case involved a patient with Strasberg E1 classification, who had already undergone Roux-en-Y hepaticojejunostomy before PTBD was attempted. The altered postoperative anatomy likely contributed to the technical failure and limited therapeutic effect of the procedure. These findings underscore that PTBD is most effective when used selectively, particularly in patients with major BDI and dilated biliary systems, and that prior surgical intervention or complex anatomy can significantly impact procedural success.

ENDOSCOPIC ULTRASOUND-GUIDED BILIARY DRAINAGE (EUS-BD)

EUS biliary drainage (EUS-BD) is increasingly used as a rescue procedure in patients with ERCP failure.[11,18] EUS-BD has been reported in previous studies to have fewer interventions, lower complication rates, and has a preferred technique over PTBD. But unfortunately, the EUS BD practitioner is not available in all centers and requires considerable expertise. In addition, PTBD has a lower cost and may be more readily available in emergency settings than EUS-BD.[11]

In this study, only two patients underwent Endoscopic Ultrasound-Guided Biliary Drainage (EUS-BD). One patient with Strasberg E2 classification experienced procedure failure, while the other, with Strasberg D classification, underwent successful metal stent placement. The limited use of EUS-BD in our study was primarily due to its high cost, which is not covered by the national health insurance system. Additionally, most patients were financially unable to bear the out-of-pocket expenses, making EUS-BD inaccessible in many cases. As a result, attending physicians were often compelled to choose for alternative, more affordable interventions to manage BDI, balancing clinical effectiveness with the socioeconomic realities of the patient population.

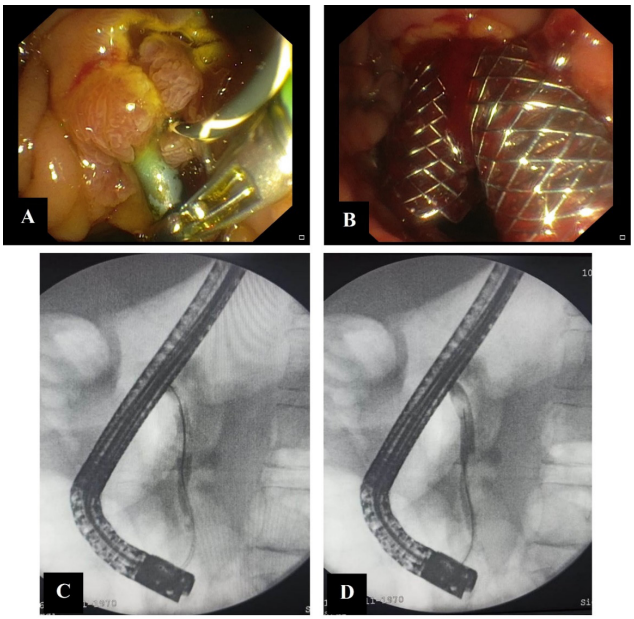

Fig.3. (A, B). EUS-BD with metal stent placement in BDI Strasberg D. (C, D). Cholangiogram imaging in patient with Strasberg E2 who experienced a failed EUS-BD procedure.

BILIODIGESTIVE SURGERY

Definitive surgical repair remains the primary procedure for BDI, especially in cases of traumatic biliary stricture. However, even in high-volume biliary surgery centers with extensive experience, the incidence of stricture after BDI repair is still 10-20%, and more than 70% of BDIs are initially repaired by surgeons who do not specialize in such repair.[14] Surgical procedures for definitive repair of BDI with Roux-en-Y hepaticojejunostomy (RYHJ) is the most widely performed and recommended treatment technique for the majority of post-cholecystectomy BDI, with a long-term clinical success rate of up to 90%.[14,15,17] Some patients undergoing hepaticojejunostomy for BDI may experience troublesome and recurrent biliary complications such as jaundice or cholangitis.[15]

Feng X. et al. stated that the surgical procedure must follow the fundamental principle of "Anastomosis and reconstruction must build upon healthy, non-ischemic, non-inflamed and non-scarred bile duct". Many repair failures are due to not following the above fundamental principles.[14] In this study, 13 out of 27 patients (48.1%) underwent biliodigestive surgery as a definitive approach to repair bile duct injury (BDI). The surgical techniques employed included common bile duct (CBD) exploratory laparotomy in 7 patients, Roux-en-Y hepaticojejunostomy in 3 patients, and gastrojejunostomy with Brown anastomosis in the remaining 3 patients. Among these 13 patients, 4 (30.8%) achieved complete resolution of the BDI, while 9 (69.2%) continued to experience biliary

stricture or leakage, indicating partial or incomplete recovery, despite observable clinical improvement in most cases. During the postoperative follow-up period, 5 patients (38.5%) unfortunately died due to sepsis, while 8 patients (61.5%) showed clinical improvement, albeit with varying degrees of anatomical recovery. The overall success rate and outcomes of the surgical procedures are detailed in Table 4, highlighting both the potential benefits and risks associated with surgical management of BDI in this study.

Table 4. Correlation Analysis of Laparoscopic Cholecystectomy, ERCP, Biliodigestive Surgery, Onset of BDI and Duration BDI to ERCP Against Outcome

Variable	Outcomes		r	p-value
	Clinical Improvement (n=19)	Died (n=8)		
	n (%)	n (%)		
Laparoscopic Cholecystectomy			0.043	0.822
OC	4 (21.1)	2 (25.0)		
LC	15 (78.9)	6 (75.0)		
ERCP			0.353	0.145
Not Performed	2 (10.5)	2 (25.0)		
Failed	7 (36.8)	5 (62.5)		
Success	10 (52.6)	1 (12.5)		
Biliodigestive Surgery			0.225	0.487
Not Performed	11 (57.9)	3 (37.5)		
Failed	5 (26.3)	4 (50.0)		
Success	3 (15.8)	1 (12.5)		
Onset of BDI			0.114	0.551
<2 weeks	7 (36.8)	2 (25.0)		
≥2 weeks	12 (63.2)	6 (75.0)		
Duration BDI to ERCP			0.057	0.958
Not performed	2 (10.5)	1 (14.3)		
<1 weeks	8 (42.1)	3 (42.9)		
≥1 weeks	9 (47.4)	3 (42.9)		

Description: Contingency Coefficient Correlation Test

DISCUSSION

Previous studies in the last three decades have shown that laparoscopic cholecystectomy (LC) has a significantly higher risk of causing BDI compared to open cholecystectomy (OC), (0.4–0.6% and 0.1–0.2%, respectively).[9] The appropriate timing for managing BDI varies based on the time of initial diagnosis. Injuries diagnosed during surgery are managed surgically in the operating room at the time, if an experienced hepatobiliary surgeon is available. Conservative therapy, endoscopic procedures, surgery or even radiological intervention can be the modality of choice in patients with early diagnosed BDI.[4] But what must be kept in mind is that management of BDI is based on a case-by-case basis and involves multidisciplinary efforts.

The primary objective of all BDI repair procedures is to restore or maintain biliary-enteric continuity, whether through percutaneous, endoscopic, or surgical approaches. For patients presenting with common bile duct (CBD) strictures and no prior surgically constructed biliary-enteric anastomosis, the first-line treatment typically involves endoscopic biliary stenting and balloon dilatation. Reported success rates for endoscopic interventions in such cases vary widely, ranging from 27% to 89%.[13] In our study, the highest success rates in BDI repair were achieved through ERCP, either as a stand-alone procedure or in combination with other interventions such as PTBD or biliodigestive surgery. Among patients with minor BDI, the success rates of endoscopic therapy ranged from 9.1% to 63.6%, depending on the Strasberg classification. Specifically, ERCP achieved a success rate of 63.6% in Strasberg A, 27.3% in Strasberg D, and 9.1% in Strasberg B. This statistically significant correlation ($p = 0.018$) underscores the crucial role of injury severity in determining the outcome of endoscopic management. Conversely, in major BDI cases (Strasberg E), ERCP demonstrated poor efficacy and is generally not recommended, as it may increase the risk of procedure-related morbidity without offering definitive therapeutic benefit. These findings reinforce the importance of stratifying treatment approaches based on BDI severity and support the use of ERCP as a viable option primarily in select cases of minor BDI.

The previous study has shown that BDI management with ERCP should be adapted to the degree and classification of underlying injury. For patients with major BDI, surgery is the primary indication and should not be delayed. Patients with such criteria will not get any benefit from endoscopy, so ERCP better not be performed because it is not necessary.[4,17] For low-flow leaks, such as gallbladder leaks, conservative management for 1-2 weeks before ERCP is highly recommended, in contrast to high-flow leaks, such as cystic duct leaks and stricture lesions that require immediate ERCP. Sphincterotomy plus stenting is the ideal and recommended first line of treatment. Interventional radiology techniques are a promising option, especially if endoscopic repair fails, and might be an option for cases with altered biliary anatomy.[4,18,19] The statements from these previous studies are in accordance with what we found in our current study.

Although this study stated that the type of previous cholecystectomy, timing of BDI diagnosis, and duration of BDI to repair procedures did not demonstrate a statistically significant association with mortality (p=0.822, p=0.551, p=0.958 respectively), these findings should be interpreted with caution. Numerous previous studies have consistently reported that delayed diagnosis, multiple failed repair attempts, and prolonged intervals before definitive treatment are strongly correlated with increased morbidity, impaired recovery, and higher mortality. Advanced clinical complications of untreated BDI can lead to chronic liver disease, liver cirrhosis, and portal hypertension, with the final therapeutic option for healing being liver transplantation.[7,9,16] Overall, the findings of this study underscore that tailored, timely interventions—ranging from ERCP to surgical reconstruction—can lead to favorable outcomes, while complex or delayed cases are more likely to be associated with poor prognosis.

Re-laparoscopy may be helpful not only in assessing and identifying the injury but also in the management of subsequent BDI, although this procedure is not recommended in current BDI management guidelines. Early diagnosed BDI within the first 72 hours are suitable candidates for re-laparoscopy. Nevertheless, BDI classification remains the most important aspect in BDI management. The choice of BDI management should always refer to several underlying factors such as the onset of BDI diagnosis, the presence of inflammation or sepsis, and coagulopathy status, although surgical reconstruction to ensure biliary continuity is the mainstay of treatment.[9] This study highlights a significant gap between current global recommendations and real-world clinical practice in our institution. Although minimally invasive therapies are widely recognized as the preferred approach for managing bile duct injury (BDI), in our setting, many clinicians still prefer relaparotomy or re-exploration of the biliary tract. This tendency is largely attributed to the absence of standardized operating procedures (SOPs) for BDI management and financial constraints, as the majority of our patients are covered under government-sponsored health insurance. Crucially, advanced endoscopic procedures such as ERCP under special circumstances and EUS-BD are not fully covered by the national insurance scheme. In particular, EUS-BD is completely excluded from government reimbursement. In contrast, biliary reconstruction surgery remains reimbursable, making it a more accessible option despite its invasiveness. These financial and systemic limitations severely restrict access to minimally invasive options, which would otherwise be the recommended standard of care for many BDI patients. As a result, clinical decisions are often driven more by resource availability than by evidence-based guidelines, underscoring the urgent need for institutional protocol development and broader insurance reform.

Foremost, management of BDI must be focuses on stabilization of general conditions, relieving local and systemic inflammatory status, drain off bilomas and evacuate abscesses, constructing biliary drainage, and discovering complete cholangiographic hallmark of the injury. The best imaging modality for BDI is MRCP.[18] Most of bilomas can be evacuated percutaneously using the Seldinger technique with imaging guidance such as ultrasonography and fluoroscopy, or CT. Delayed drainage of bilomas is associated with an increased risk of more serious complications, such as abscess, cholangitis, and sepsis. Bile leaks from small peripheral ducts (eg, ducts of Luschka) can be managed definitively with a combination of percutaneous drainage and PTBD or biliary stent placement via ERCP to turn bile flow away from the leak site.[13] Once the patient is stable and the BDI lesion imaging has been obtained, further repair procedures must be taken immediately. This study clearly illustrates that BDI lesion stratification plays a major role in determining further repair procedures. The procedure chosen might be one stand-alone procedure, or a combination of several sequential procedures, by considering the success rate, risk or procedural adverse events and long-term outcomes, especially those that affect the quality of life of the subjects.

BDI prevention remains a key aspect of implementing the surgeon's learning curve. BDI prevention is accomplished through providing comprehensive knowledge of the mechanisms of BDI, understanding critical views on safety, and appropriate patient selection.[9,20] The implementation of "Bailout" operation in cases of unclear anatomy has been implemented in the World Society of Emergency Surgery (WSES) Guidelines in 2020, to prevent BDI. Conversion from LC to OC procedure aimed at improving surgical visualization does not provide enough evidence to support the fact that this conversion can reduce the incidence of BDI.[9]

CONCLUSION

Prevention of Bile Duct Injury (BDI) is a critical component of the surgical learning curve and must be prioritized, particularly in training environments. In

teaching hospitals, strict supervision by experienced surgeons is essential when new surgeons perform laparoscopic or open cholecystectomy (LC or OC). Advanced biliary procedures should only be undertaken by skilled and experienced hepatobiliary surgeons to ensure patient safety and optimal outcomes.

BDI management should always be individualized, discussed on a case-by-case basis, based on the classification and timing of the injury. Ideally, repair should be performed once inflammation has subsided and the patient is stabilized, reducing the risk of further complications. There is no single repair technique that guarantees complete recovery in all cases, highlighting the importance of a tailored, case-by-case approach to each BDI.

This study is not without limitations—namely, a small sample size and retrospective design. Nonetheless, it provides valuable insights into the real-world challenges and learning opportunities associated with gallbladder surgery and BDI management. While statistically significant associations were not observed, this may be attributed to the limited sample size. As a tertiary referral center, our institution likely receives a higher proportion of complex and severe BDI cases, contributing to the observed mortality rate and introducing a degree of referral bias. To advance the field and validate our observations, larger prospective multicenter studies are urgently needed.

Importantly, our findings emphasize the need for a unified institutional standard operating procedure (SOP) for BDI management. The development and consistent implementation of such clinical protocols will help reduce treatment variability, support evidence-based decision-making, and ultimately lead to improved patient outcomes.

REFERENCES

1. Hao Sun, Jonathan Warren, James Yip, Yu Ji, Shaolong Hao, Wei Han, and Yuchuan Ding. (2022). Factors Influencing Gallstone Formation: A Review of the Literature. Biomolecules, 12, 550. | https://doi.org/10.3390/biom12040550
2. Stinton L, Myers R, Shaffer E. Epidemiology of gallstones. Gastroenterol Clin North Am [Internet] 2010;39(2):157–69. Available from: https://pubmed. ncbi.nlm.nih.gov/20478480/
3. Alexander Harry C., Bartlett Adam S., Wells Cameron I., Hannam J.A., Moore Matthew R., et al. Reporting of complications after laparoscopic cholecystectomy: a systematic review. International Hepato-Pancreato-Biliary Association Inc. 2018, 20, 786–794. | https://doi.org/10.1016/j.hpb.2018.03.004
4. Emara MH, Ahmed Mohammed H, Radwan Mohamed I, Emara EH, Basheer M, et al. Post-cholecystectomy iatrogenic bile duct injuries: Emerging role for endoscopic management. World J Gastrointest Surg 2023 December 27; 15(12): 2709-2718. | DOI: 10.4240/wjgs.v15.i12.2709
5. Brunt L. Michael, Deziel Y. Daniel J, Telem Dana A., Strasberg Steven M., Aggarwal Rajesh, Asbun Horacio, et al. Safe Cholecystectomy Multi-society Practice Guideline and State of the Art Consensus Conference onPrevention ofBile Duct Injury During Cholecystectomy. Annals of Surgery Volume XX, Number XX, Month 2020. | DOI: 10.1097/SLA.0000000000003791
6. Nicola de'Angelis, Fausto Catena, Riccardo Memeo, Federico Coccolini, Aleix Martínez-Pérez, Oreste M. Romeo, et al. 2020 WSES guidelines for the detection and management of bile duct injury during cholecystectomy. World Journal of Emergency Surgery (2021) 16:30. | https://doi.org/10.1186/s13017-021-00369-w
7. Miguel Angel Mercado, Ismael Domínguez. Classification and management of bile duct injuries. World J Gastrointest Surg 2011 April 27; 3(4): 43-48. | doi:10.4240/wjgs.v3.i4.43
8. Kwangsik Chun. Recent classifications of the common bile duct injury. Korean J Hepatobiliary Pancreat Surg 2014;18:69-72. | http://dx.doi.org/10.14701/kjhbps.2014.18.3.69
9. Zidan Mohamed H. El-Din, Seif-Eldeen M., Ghazal Abdelhamid A., and Refaie M. Post-cholecystectomy bile duct injuries: a retrospective cohort study. BMC Surgery (2024) 24:8. | https://doi.org/10.1186/s12893-023-02301-2
10. Emara Mohamed H.a; Ali Reda F.b; Mahmoud Ramadan c; Mohamed Salem Y.d. Post cholecystectomy biliary injuries: frequency, and role of early versus late endoscopic retrograde cholangiopancreatography. European Journal of Gastroenterology & Hepatology 33(5):p 662-669, May 2021. | DOI: 10.1097/MEG.0000000000002086
11. Verma, Nikita et al. Role of Percutaneous Transhepatic Biliary Drainage as an Adjunct to Endoscopic Retrograde Cholangiopancreatography. Journal of Clinical and Experimental Hepatology, Volume 12, Issue 2, 287 – 292. https://doi.org/10.1016/j.jceh.2021.09.002
12. Deniz et al. Percutaneous transhepatic biliary drainage (PTBD) in patients with biliary leakage Technical and clinical outcomes. Deniz et al. • Medicine (2023) 102:37. http://dx.doi.org/10.1097/MD.0000000000035213
13. Thompson et al. Management of Iatrogenic Bile Duct Injuries: Role of the Interventional Radiologist. RadioGraphics 2013; 33:117–134. DOI : 10.1148/rg.331125044
14. Feng X., Dong J. Surgical management for bile duct injury. BioScience Trends Advance Publication. 2017. DOI: 10.5582/bst.2017.01176
15. Hamida Mohamed A.S.A., Nasserb Haytham M., Sayeda H. Biliary stricture after Roux-en-Y hepaticojejunostomy for bile duct injury–surgical challenge: a single-center expertise. The Egyptian Journal of Surgery 2020, 39:393–400. DOI: 10.4103/ejs.ejs_224_19
16. Gupta RK, Agrawal CS, Sah S, Sapkota S, Pathania OP, Sah PL. Bile Duct Injuries during Open and Laparoscopic Cholecystectomy: Management and Outcome. J Nepal Health Res Counc 2013 May;11(24):187-93.
17. Kalyanashanmugam S., Mohan K., Shanmugasundaram R., Babu Obla L.N. Bile Duct Injuries after Cholecystectomy-Problems in Management. Journal of Dental and Medical Sciences (IOSR-JDMS). Volume 18, Issue 6 Ser. 10 (June. 2019), PP 01-10. DOI: 10.9790/0853-1806100110
18. Facciorusso A., Crinò S.F., Gkolfakis P., Spadaccini M. et al. Diagnostic work-up of bile duct strictures: European Society of Gastrointestinal Endoscopy (ESGE) Guideline. Endoscopy 2025; 57: 166–185. DOI 10.1055/a-2481-7048

19. American Society for Gastrointestinal Endoscopy. The role of ERCP in benign diseases of the biliary tract. Volume 81, No. 4 : 2015 Gastrointestinal Endoscopy. http://dx.doi.org/10.1016/j.gie.2014.11.019
20. Eikermann M., Siegel R., Broeders I., Dziri C., Fingerhut A. Prevention and treatment of bile duct injuries during laparoscopic cholecystectomy: the clinical practice guidelines of the European Association for Endoscopic Surgery (EAES). Surg Endosc 2012. DOI 10.1007/s00464-012-2511-1