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Correlation of Injury Classification with Surgical Management and Outcomes in Post-Cholecystectomy Bile Duct Injuries

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Abstract | **Original Research Article**

Background: Bile duct injury (BDI) remains a serious complication following laparoscopic cholecystectomy, significantly impacting patient morbidity, surgical complexity, and long-term outcomes. Optimal management depends on timely diagnosis and accurate classification of the injury. This study aimed to correlate BDI classification, as per the Bismuth system, with the type of surgical management utilized and corresponding clinical outcomes. ***Methods:*** A cross-sectional observational study was conducted over one year across five tertiary hospitals in Dhaka, Bangladesh. Twenty patients diagnosed with post-laparoscopic cholecystectomy BDI within six months of surgery were enrolled. Clinical records, imaging, and laboratory tests were reviewed. Injuries were classified according to the Bismuth system. Surgical management strategies, perioperative findings, complications, and follow-up outcomes were documented and analyzed using SPSS version 25.0. ***Results:*** The most frequent injury types were Bismuth Grade 2 (35%) and Grade 3 (30%). Controlled biliary fistula (45%) and Roux-en-Y hepaticojejunostomy (30%) were the predominant surgical interventions. Subhepatic collections (75%) and high-level strictures (40%) were common intraoperative findings. Postoperative complications included wound infection (30%), chest infection (15%), and one mortality (5%). Follow-up revealed that 40% of patients were asymptomatic, while 20% experienced recurrent cholangitis and 5% developed strictures. ***Conclusion:*** A significant correlation exists between BDI classification and the choice of surgical approach. Early recognition, precise injury grading, and multidisciplinary care are critical for improving outcomes in BDI management.

Keywords: Bile duct injury, Laparoscopic cholecystectomy, Bismuth classification, Hepaticojejunostomy, Surgical outcomes.

INTRODUCTION

Laparoscopic cholecystectomy (LC) has become the gold standard for the treatment of symptomatic gallstone disease due to its advantages in reduced postoperative pain, shorter hospital stays, and faster recovery compared to open cholecystectomy [1]. Despite its widespread adoption and minimally invasive nature, LC is associated with a notable complication—bile duct injury (BDI), which carries significant morbidity and mortality risks [2]. The incidence of BDI after LC is reported to range between 0.3% and 0.6%, which is higher than that associated with the traditional open technique [3,4].

BDI can result in long-term adverse outcomes, including biliary strictures, recurrent cholangitis, secondary biliary cirrhosis, liver failure, and even death [5,6]. Studies have also shown that such injuries have profound effects on patients' quality of life, increase litigation risks, and impose a considerable economic burden on the healthcare system [7]. The mechanisms contributing to BDIs include anatomical misidentification, inflammation obscuring the biliary

tree, surgeon inexperience, and lack of routine intraoperative cholangiography [1].

Several classification systems have been developed to stratify BDIs, with the Bismuth classification being one of the most widely accepted for characterizing the level and extent of injury [8]. This classification is critical for determining the appropriate surgical intervention. Minor injuries, such as leaks from accessory ducts, may be managed endoscopically, while complex injuries often necessitate reconstructive surgery such as hepaticojejunostomy [9]. Moreover, high-grade injuries involving vascular or bowel structures may require advanced surgical techniques, including liver resection or even transplantation [10,11].

While considerable research has been dedicated to the identification and management of BDIs, limited studies have correlated specific injury classifications with surgical outcomes. A multidisciplinary approach involving gastroenterologists, interventional radiologists, and hepatobiliary surgeons has been recommended to optimize outcomes, particularly in tertiary referral centers [12,13]. However, most existing studies focus on individual aspects such as timing of repair, types of reconstruction, or specific complications, rather than presenting a holistic overview linking injury grades with operative difficulties and long-term outcomes.

In this context, our study aims to bridge this knowledge gap by systematically analyzing the correlation between BDI classification according to Bismuth, surgical interventions performed, perioperative complications, and follow-up outcomes. Understanding these relationships is essential not only for improving surgical planning and management but also for patient counselling and prognostication. Given the potential for devastating complications, this analysis can contribute significantly to formulating standardized protocols for the timely and effective management of BDIs.

This study was conducted in several tertiary hospitals in Dhaka, Bangladesh, with a focus on post-cholecystectomy patients presenting with BDIs. By evaluating clinical data from 20 cases, we aim to provide a comprehensive assessment of the injury spectrum and its implications for surgical strategy and patient prognosis.

METHODOLOGY & MATERIALS

This cross-sectional observational study was conducted from January 2013 to December 2013 in various tertiary care hospitals in Dhaka, including the Department of Surgery in Bangabandhu Sheikh Mujib Medical University (BSMMU), BIRDEM General Hospital, Dhaka Medical College Hospital, Suhrawardy Medical College Hospital, and Sir Salimullah Medical College Mitford Hospital. A total of 20 patients were included in the final analysis. All participants were diagnosed with bile duct injuries (BDIs) following laparoscopic cholecystectomy.

Sample Selection

Inclusion Criteria:

- Patients with a history of laparoscopic cholecystectomy.
- Postoperative diagnosis of bile duct injury.
- Bile duct injury was identified within six months of the cholecystectomy.

Exclusion Criteria:

- Bile duct injury is associated with choledocholithiasis.
- Cases requiring hepaticojejunostomy unrelated to laparoscopic cholecystectomy.
- Bile duct injuries in patients with cholangiocarcinoma.
- Patients who underwent gastrectomy.
- Bile duct injuries following T-tube extraction.
- Laparoscopic cholecystectomy was performed more than six months prior.

Data Collection Procedure:

Data were collected using structured, pre-designed data collection sheets. Primary data sources included patient interviews, clinical examinations, laboratory investigations, and imaging studies. Additional demographic and clinical details were confirmed via review of hospital records. Data collected included age, gender, injury classification (Bismuth), type of treatment, intraoperative findings, postoperative complications, and follow-up outcomes.

Ethical consideration:

Ethical clearance was obtained from the institutional review boards of BSMMU and BIRDEM. All participants provided written informed consent after being fully informed in their native language about the study's nature, risks, and benefits. Confidentiality and privacy of patient information were strictly maintained throughout the study.

Statistical Analysis:

All collected data were entered and analyzed using SPSS version 25.0. Descriptive statistics, including frequencies and percentages, were calculated to summarize demographic variables, injury classification, treatment modalities, intraoperative findings, complications, and follow-up outcomes. Inferential statistics, such as the chi-square test, were applied where relevant to determine associations between categorical variables. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

Table 1: Age distribution of the study population having bile duct injury (n=20)

Age groups	Number of patients	Percentage (%)
20-29	3	15.0
30-39	7	35.0
40-49	5	25.0
50-59	2	10.0
60-69	1	5.0
≥70	1	5.0

Table 1 shows the distribution of patients by age group. The highest number of patients (35%) were aged between 30–39 years, followed by 25% in the 40–49 age group. The 20–29 group comprised 15%, while patients aged 50–59 constituted 10%. Only one patient each (5%) was in the 60–69 and ≥70 years age groups.

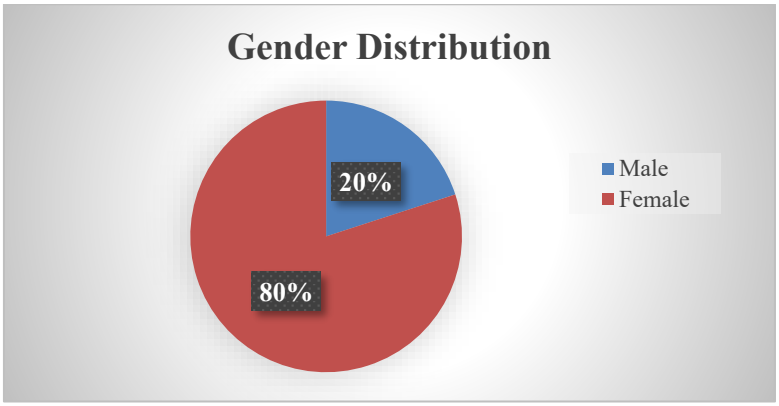

Figure 1: Gender distribution of the study population with bile duct injury (n=20)

Figure 1 illustrates the gender distribution among patients with BDI. Of the 20 patients, the majority were female, consistent with the higher prevalence of gallbladder disease and cholecystectomy procedures among women.

Table 2: Type of injury according to bismuth classification (n=20)

Bismuth classification	Number of cases	Percentage (%)
Bismuth Grade-1	5	25.0
Bismuth Grade-2	7	35.0
Bismuth Grade-3	6	30.0
Bismuth Grade-4	2	10.0
Bismuth Grade-5	1	5.0

Table 2 presents the classification of injuries based on the Bismuth grading system. Bismuth Grade-2 injuries were the most frequent, observed in 35% of patients. Grade-3 injuries accounted for 30%, while Grade-1 injuries were found in 25%. More severe injuries (Grades 4 and 5) were less common, with 10% and 5% prevalence, respectively.

Table 3: Specific treatment performed (n=20)

Procedures	Number of cases	Percentage (%)
Endoscopic procedure		
ERCP-Endoprosthesis	2	10.0
Operative procedure		
Roux-en-Y Hepaticojejunostomy	6	30.0
Controlled biliary fistula	9	45.0
Liver resection with Roux-en-Y cholangiojejunostomy	1	5.0
Portal vein repair associated with bile duct injury	1	5.0
Small bowel repair associated with bile duct injury	1	5.0

Table 3 outlines the treatment strategies employed. The most common procedure was controlled biliary fistula in 45% of cases. Roux-en-Y hepaticojejunostomy was performed in 30%, while ERCP with endoprosthesis accounted for 10%. Liver resection with Roux-en-Y cholangiojejunostomy, portal vein repair, and small bowel repair were each performed in one patient (5% each).

Table 4: Per operative difficulties encountered (n=20)

Difficulties	Number of cases	Percentage (%)
Stricture (High level)	8	40.0
Dense adhesion & fibrosis	5	25.0
Sub hepatic collection	15	75.0
Gross hepatomegaly	2	10.0
Associated vascular injury	1	5.0
Associated bowel injury	1	5.0

Table 4 describes intraoperative complications. Subhepatic collection was the most common finding, present in 75% of patients. High-level biliary strictures occurred in 40%, while dense adhesions and fibrosis were encountered in 25%. Gross hepatomegaly, vascular injury, and bowel injury were each identified in one patient (5%).

Table 5: Complications during post operative period (n=20)

Complications	Number of patients	Percentage (%)
Wound infection	6	30.0
Minor bile leak	2	10.0
Peritonitis	2	10.0
Renal impairments	1	5.0
Chest infection (pneumonia)	3	15.0
Mortality	1	5.0

Table 5 lists postoperative adverse events. Wound infection was the most frequent complication, occurring in 30% of patients. Chest infections (15%), minor bile leaks (10%), peritonitis (10%), and renal impairments (5%) were also observed. There was one case of mortality (5%).

Table 6: Follow up results (n=20)

Features	Number of cases	Percentage (%)
No. of patients come for follow up	14	70.0
No complaint	8	40.0
Recurrent cholangitis	4	20.0
Secondary biliary cirrhosis	1	5.0
Restricture	1	5.0

Table 6 details the follow-up findings. Fourteen patients (70%) returned for follow-up. Of these, 40% had no complaints. Recurrent cholangitis was reported in 20%, while stricture and secondary biliary cirrhosis were observed in one patient each (5%).

DISCUSSION

Bile duct injury (BDI) remains a significant complication following laparoscopic cholecystectomy, with potential for long-term morbidity and even mortality. The findings of this study align with established literature in highlighting the clinical burden of BDI, while also contributing new insight by correlating Bismuth classification with treatment strategies and patient outcomes.

In the present series, the highest number of both males & females is in the age group of 41-50, followed by the 31-40 years age group. Females were predominating as per sex was concerned in each age group. The finding indicates that people in a young and active state, especially females, are the common sufferers. Thus, age & sex distribution are almost similar to the study conducted by Mirza, D-F *et al.,* [13]. In this study, females outnumbered the male patients. This higher incidence of injury in females is probably due to the fact that gallstone disease is more common in females. This report is consistent with the report of Slater, K *et al.,* [14].

In our study, most of the cases were Bismuth grade 1(25%), grade 2 (35%), grade 3 (30%) and grade 4 (10%). A study conducted in France showed Bismuth grade 1 2,3,4,5 injuries were 15%, 23%, 25%, 20%, 17%, respectively [4]. The outcome was dependent on the Bismuth level. A study by Dr. Olsan of Baptist Hospital in Nashville recently reported 117 laparoscopic bile duct injuries & found the commonest type was Bismuth grade

3 [15]. Concomitant hepatic arterial injury was identified in 12% of patients in a study [16]. In our study, we have dealt with 1 portal vein injury and one small bowel injury. So, our study coincides with that of others.

Management strategies for bile duct injuries are complex and vary from one case to another. In our series, controlled biliary fistula was done in 9 patients (45%), ERCP-Endoprosthesis in 2 patients (10%), Roux-en-Y hepaticojejunostomy in 6 patients (30%), Liver resection with Roux-en-Y Cholangiojejunostomy was done in 1 case with grade 4 injuries. Portal vein repair and small bowel repair were done in one case each. According to Lillemoe *et al.,* the most commonly employed surgical procedure (85%-90% cases) with the best overall results is a Roux-en-Y hepatojejunostomy [17], Segmental liver resection may serve an important role in the management of carefully selected patients with high-grade injuries [18]. Definitive operation, almost always a Roux-en-Y hepaticojejunostomy, was required in 45% of patients in a study. In another study, 21 out of 27 patients (77%) underwent Roux-en-Y hepaticojejunostomy. So, our study is consistent with these published reports.

In this study, during repair, we encountered adhesion and some difficulties as high-grade stricture, gross fibrosis, subhepatic collection, gross hepatomegaly, and associated vascular & bowel injury. These were managed accordingly. In a study. Most operative difficulties were fibrosis or difficulty in delineating the anatomy of biliary tree [19]. These reports support our study.

In our series, wound infection (30%) was the most frequent complication, followed by minor bile leak, peritonitis, renal impairment, and chest infection. In our series average hospital stay was 20 days (range 15-60 days).

In this study, out of 20 patients, 14 (70%) came for follow-up for over 6 months. Among them, 4 patients complained of cholangitis. 1 patient came with restriction, and 1 patient came with secondary biliary cirrhosis. Secondary biliary cirrhosis developed in this patient before he presented to us. An excellent to good outcome was in more than 50% (8 out of 14 cases). In a study in Singapore, 3 out of 18 hepaticojejunostomies developed stricture subsequently, 1 patient developed intrahepatic stones and required a left segmentectomy [20]. In another study, 9% patients developed subsequent anastomotic stricture and were treated with percutaneous dilatation, endoscopic dilatation and revision surgery. Excellent to good long-term results were achieved in 60% patients [21]. The majority of the patients treated with operative repair at an experienced center can expect good long-term results with rare need for reintervention [22]. In another study overall success rate was 64% following definitive repair; there was one death (1.6%) and one late structure requiring surgical revision [23].

In a study by Bauer-T-W *et al.,* 1998, at follow-up, 62% remained asymptomatic with normal liver function test. 28% experiencing episodic cholangitis, 10% asymptomatic with persistently elevated liver enzymes [24]. In our study. Approaches to follow up in our series ranged from simple observation. Measurement of liver function test, abdominal USG, and MRCP. Tocchi A. observed that the best results correlated directly with the degree of biliary ductal dilatation [25]. It has been suggested that laparoscopic bile duct injuries may have a less satisfactory outcome because of the more complex nature of injuries and the frequent inflammation and fibrosis secondary to bile leakage [26].

Our findings reaffirm the critical role of injury classification in guiding surgical management. Timely recognition, appropriate stratification of treatment, and multidisciplinary involvement are vital to optimize outcomes in patients with BDI following laparoscopic cholecystectomy.

Limitations and Recommendations

The primary limitation of this study is its small sample size, which may affect the generalizability of findings. Additionally, it was conducted in a single geographic region and lacked long-term follow-up for all patients. Future research should involve multicenter studies with larger populations and extended follow-up periods to assess the durability of surgical outcomes and quality of life.

CONCLUSION

This study highlights a clear correlation between the severity of bile duct injury, as classified by the Bismuth system, and the complexity of surgical intervention and patient outcomes. Bismuth Grade 2 and 3 injuries were most common and often required reconstructive procedures such as hepaticojejunostomy. Perioperative challenges and postoperative complications were more frequent in higher-grade injuries. Timely diagnosis, proper injury classification, and individualized surgical planning are essential for optimizing outcomes. These findings underscore the importance of specialized care, multidisciplinary involvement, and early referral to hepatobiliary centers for effective management of bile duct injuries following laparoscopic cholecystectomy.

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Conflicts of Interest: There are no conflicts of interest.

Ethical Approval: The study was approved by the Institutional Ethics Committee.

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