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Original Research Article

Retrospective Assessment of Bile Duct Injury Occurrence in Laparoscopic Cholecystectomy

Ravi Kant Kumar[1], Md. Sabitulla Ansari[2], Kishor Kumar Sinha[3], Dikshant Bhati[4], Md Faizal Azhar[5]

[1]Senior Resident, Department of General Surgery, Anugrah Narayan Magadh Medical College and Hospital, Gaya ji, Bihar, India

[2]Senior Resident, Department of General Surgery, Anugrah Narayan Magadh Medical College and Hospital, Gaya ji, Bihar, India

[3]Professor, Department of General Surgery, Anugrah Narayan Magadh Medical College and Hospital, Gaya ji, Bihar, India

[4]PG-Student, Department of General Surgery, Anugrah Narayan Magadh Medical College and Hospital, Gaya ji, Bihar, India

[5]PG-Student, Department of General Surgery, Anugrah Narayan Magadh Medical College and Hospital, Gaya ji, Bihar, India

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Corresponding Author: Dr. Md. Sabitulla Ansari

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Abstract:

Background: Laparoscopic cholecystectomy (LC) is the treatment of first choice in the case of gallstone disease, whereas bile duct injury (BDI) remains the severe adverse event that has a high morbidity. Knowledge of modern incidences, risk factors and outcomes is crucial in enhancing patient management.

Hypothesis: To retrospectively determine the incidence, nature and treatment of bile duct trauma in patients who undergo LC in a tertiary care hospital.

Methodology: It is a retrospective observational study that analyzed 576 records of patients in ANMMCH, Gaya ji,Bihar. The data analyzed were demographic, clinical, and operative data. Strasberg-Bismuth and McMahon systems were used to classify BDIs. The relationship between risk factors and BDI was tested using Chi-square or Fisher exact tests ($p \leq 0.05$).

Result: CBD damage was observed in 5 (0.9) patients. BDI was not significantly related to age, gender and most comorbidities except renal disease ($p=0.024$). After Strasberg-Bismah type A (60 percent), type D (20 percent), and type E1 (20 percent) ranked as the most frequent injuries, 60 percent were minor injuries, and 40 percent were major injuries per McMahon. ERCP and stenting were administered to control four patients, and one patient underwent surgical repair. A majority of the injuries were postoperative.

Conclusion: BDI in LC is uncommon, yet of clinical significance. Kidney disease can be a risk factor, and injuries can be minor or severe. Timely identification, proper categorization, and specific management are essential to achieve the best results.

Keywords: Laparoscopic Cholecystectomy, Bile Duct Injury, Strasberg-Bismuth Classification, McMahon Classification, ERCP, Risk Factors.

Introduction

Laparoscopic cholecystectomy (LC) has become one of the most common types of surgery that are practiced in modern general surgery, and it is the most common standard of managing symptomatic stones of the gallbladder [1]. LC has dominated open cholecystectomy (OC) because since its introduction in the late 1980s, LC has many benefits such as less postoperative pain, shortened hospital stay, enhanced cosmetic appearance, and faster recovery to normal activities [2]. These advantages have made LC a first-line therapeutic modality in the treatment of cholelithiasis supersede its global use very fast. Nonetheless, regardless of the growing complexity of laparoscopic procedures, LC is still linked with certain complications, which are not identical in nature and rates compared to those with open surgeries.

Bile duct injury (BDI) is one of the most alarming complications of LC, though it is not frequent, its short and long-term impact is severe. The visual and tactile feedback that the surgeons receive also changes due to the minimal invasiveness of LC, and anatomical recognition in the hepatobiliary triangle

can be difficult in some cases. The laparoscopic view, low depth perception and a large occurrence of inflammation or anatomical variations may predispose the misidentification of structures (cystic duct, common hepatic duct or common bile duct). Consequently, LC exhibits a relatively high bile leak and bile duct injury than OC [3]. Despite the low levels of the incidence of BDI, its effect is severe because it may require complicated reconstructive interventions, long hospital stay, and lifelong complications [4].

The clinical implications of BDI are not limited to the direct postoperative period. During the initial stage, the patients can have bile leakage, abdominal sepsis, or biliary peritonitis, and these conditions need immediate treatment. The long-term complications are recurrent or persistent strictures of the common bile duct, secondary biliary cirrhosis, recurrent cholangitis and high morbidity, which may negatively impact the quality of life [5]. In certain instances, it might need repeated interventions or reoperations, which will pose a significant burden to the healthcare sector and the affected individuals. Thus, it is crucial to comprehend the modern occurrence, trend, and risk indexes of BDI in order to gain better patient outcomes and enhance surgical education and guidelines.

Gallstone disease is a significant health issue of concern to the general population, and its prevalence is on the rise across the world, which is a result of lifestyle change, metabolic disorders and dietary patterns. This has led to an increase in the number of patients that have undergone LC. The continued assessment of the results of perioperative activities including the BDI is of utmost importance in environments where LC is practiced regularly to ensure the high standards of care are met. The assessment of these outcomes helps not only to determine the trends and possible factors contributing to adverse events but also to help the institutions change clinical routes, improve surgical education, and impose compliance with evidence-based safety concepts like the Critical View of Safety (CVS). Because of the dynamic nature of surgical activity, changes in technology, and continuous improvements in the field, it is necessary to reevaluate the outcomes of the operations with certain time intervals in order to provide safe and effective treatment [6].

Past research studies in India have documented complication pattern in relation to LC and identified the factors that contribute to the development of BDI such as severity of inflammation, experience in the practice by the surgeon, abnormalities of the anatomy and methods used during surgery. Nevertheless, most of these studies are old, or even concentrate on a small sample, specialty, or subpopulation. In a time of ever-changing surgical training, better imaging techniques, and more advanced intraoperative technology, new evidence is needed to represent the new clinical environment. Moreover, continuous quality improvement requires that surgical results be periodically revisited so that the practice patterns can be kept consistent with the global standards and those aspects that need additional development are determined.

This necessity of a continuous assessment is the ground upon which the current research is based. As a large tertiary care hospital, Combined Military Hospital (CMH), Rawalpindi handles a high number of patients with gallbladder disease and does LC on a daily basis. It has a high case turnover level, which presents the perfect environment to conduct a retrospective evaluation of BDI prevalence. Researching the prevalence, nature, and situation of BDI in an institution of this scale like CMH gives a prospective insight into the actual results and the performance of the institution. Also, the results could be used to add to the national data repositories, shape local and regional policies, and inform the capacity-building efforts, including surgeon training, operative checklists, and simulations learning.

Thus, the proposed study will be a retrospective assessment attempt to investigate the evidence of bile duct injury in patients who receive laparoscopic cholecystectomy in CMH Rawalpindi. The study aims to provide valuable evidence that will help clinicians to improve the decision-making process at surgery and positively impact patient safety by analyzing the patterns of injury, risk factors, and clinical outcomes. Finally, the experience obtained in relation to this evaluation would assist in achieving efficiency of management practices and in providing patients with the best possible level of care in accordance with modern evidence-based surgical practices.

Methodology

Study Design: The study was done as a retrospective observational study that sought to determine incidence and nature of bile duct injuries (BDI) in the patients who had laparoscopic cholecystectomy. The research was conducted through the review and analysis of the available records in the hospitals, operative notes, and follow-ups.

Study Area: The study was carried out in the Department of General Surgery, Anugrah Narayan Magadh Medical College and Hospital (ANMMCH), Gaya, Bihar, India.

Study Duration: The study was conducted over a period of six months.

Sample Population: The study population consisted of all patients who underwent laparoscopic cholecystectomy at ANMMCH during the study period.

Sample Size: A non-probability consecutive sampling technique was used, including all eligible

patient records available during the defined study duration.

Data Collection: The data were collected by reviewing the hospital operative registers, patient case files, electronic medical records, and postoperative follow-up charts in detail. Data on demographic features, including age and gender, clinical history, presence or absence of comorbid conditions, including diabetes, hypertension, dyslipidemia, renal disease, pancreatitis, and laparotomy history, and the condition manifestations of cholecystitis were obtained. Operative specifications were reviewed to determine whether there was any intraoperative complication, especially bile duct injuries. The postoperative records until 30 days were reviewed to record cases of delayed identification of bile duct injury, a postoperative bile leak, strictures, or any other complication of the biliary. Any injury that was present was classified under the Strasberg-Bismuth system and its severity under the classification criteria of McMahon.

Inclusion Criteria

- Patients aged 18–70 years of either gender.
- Patients who underwent laparoscopic cholecystectomy at ANMMCH during the study period.
- Patients whose postoperative follow-up records (at least 30 days) were available.

Exclusion Criteria

- Patients with congenital or hematological disorders such as thalassemia, iron deficiency anemia, or other blood-related diseases.
- Patients converted to open cholecystectomy before any dissection of biliary structures.
- Incomplete medical records or loss of follow-up.
- Patients unwilling to allow use of their data for research (where consent was documented).

Procedures

The research was conducted in an organized process that involved the extraction of patient records in the surgical archives and the hospital database. All the files were filtered as complete and eligible according to the inclusion and exclusion criteria. Cases of laparoscopic cholecystectomy were then reviewed in the search of any reports of bile duct injury during surgery or during the 30 days follow-up period. On identifying an injury, their anatomical pattern was identified by Strasberg-Bismuth criteria and the severity of the injury - minor or major- was identified using McMahon classification system. Upon the classification, all the variables of interest were aggregated into a structured data set, which was meant to be analyzed statistically.

Statistical Analysis: The statistical analysis was done with the help of SPSS software version 24.0. Other quantitative variables including age and BMI were summarized as mean +- standard deviation. All qualitative variables such as gender, comorbidities, operative findings and incidence of Bile duct injury were provided as frequencies and percentages. The connection between possible risk factors and the frequency of bile duct injury was assessed by Chi-square test or Fisher-Precise test based on data distribution. All inferential tests were statistically significant when ≤0.05 was used.

Result

Table 1 provides a comparison of common bile duct (CBD) injury incidence and status of the baseline parameters in 576 patients. In total, 5 patients (0.9%) had CBD injuries. The age factor was not significantly associated with it, as 1.1% of patients ≤50 years and 0.7% of patients older than 50 years have been affected by CBD injury (p = 0.6709). Gender was not important, either, as there were 0.6 percent of female and 1.3 percent of male victims (p = 0.4026). Cholecystitis (2.1% vs. 0.5%, p = 0.1063), previous laparotomy (1.5% vs. 0.7%, p = 0.3232), pancreatitis (2.1% vs. 0.6%, p = 0.199), bleeding (0.9% vs. 0.8%, p = 1), hypertension (1.0% vs. 0.7%, p = 1), and dyslipidemia (1.9 Nonetheless, renal disease was largely linked to increased incidence of CBD injury (3.6% vs. 0.4% p = 0.0241). The patterns of obesity were positively oriented towards increased incidence (1.6% vs. 0%, p = 0.0702) but failed to become statistically significant. On the whole, Table 1 shows that the majority of the baseline traits were not significantly related to the CBD injury, except renal disease.

Table 1: Comparison of Incidence of CBD Injury with Baseline Characteristics (n = 576)

Variables	Total	Incidence of CBD Injury		p-value
		Yes (n = 5)	No (n = 571)	
Age, years				
≤50	272	3 (1.1%)	269 (98.9%)	0.6709
>50	304	2 (0.7%)	302 (99.3%)	
Gender				
Female	341	2 (0.6%)	339 (99.4%)	0.4026
Male	235	3 (1.3%)	232 (98.7%)	
Risk Factors				
Cholecystitis				
Yes	146	3 (2.1%)	143 (97.9%)	0.1063

No	430	2 (0.5%)	428 (99.5%)	
Previous Laparotomy				
Yes	132	2 (1.5%)	130 (98.5%)	0.3232
No	444	3 (0.7%)	441 (99.3%)	
Pancreatitis				
Yes	97	2 (2.1%)	95 (97.9%)	0.199
No	479	3 (0.6%)	476 (99.4%)	
Bleeding				
Yes	211	2 (0.9%)	209 (99.1%)	1
No	365	3 (0.8%)	362 (99.2%)	
HTN				
Yes	297	3 (1.0%)	294 (99.0%)	1
No	279	2 (0.7%)	277 (99.3%)	
Dyslipidemia				
Yes	104	2 (1.9%)	102 (98.1%)	0.223
No	472	3 (0.6%)	469 (99.4%)	
Renal Disease				
Yes	84	3 (3.6%)	81 (96.4%)	**0.0241**
No	492	2 (0.4%)	490 (99.6%)	
Obesity				
Yes	322	5 (1.6%)	317 (98.4%)	0.0702
No	254	0 (0.0%)	254 (100%)	

Table 2 outlines the nature and management of the five patients who suffered bile duct injury. The patients were aged 44-61 years old with three males and two females with BMI of 25.7 and 29kg/m2 respectively. The time taken between diagnosis and final treatment was between 10 and 24 days. This was rated as three Type A, one Type D and one Type E1 injuries according to the Strasberg-Bismuth classification and three minor and two major injuries according to the McMahon classification. Majority of the injuries were diagnosed after the operation (4/5), with one being diagnosed during the operation. The treatment was mainly dominated by ERCP using stents (4/5 patients), with only one patient having a major Type E1 injury without stents in the biliary surgery.

Table 2: Characteristics of Patients with Bile Duct Injury (n = 5)

Age, years	Gender	BMI (kg/m²)	Diagnosis to Definitive Treatment (days)	Strasberg-Bismuth	McMahon Classification	Diagnosis	Treatment
49	Female	26.4	18	Type A	Minor	Postoperative	ERCP and Stent
52	Male	27.9	24	Type D	Major	Intraoperative	ERCP and Stent
44	Male	28.1	12	Type A	Minor	Postoperative	ERCP and Stent
56	Female	25.7	16	Type E1	Major	Postoperative	Biliary Surgery
61	Male	29	10	Type A	Minor	Postoperative	ERCP and Stent

Table 3 demonstrates the common bile duct injuries distribution of the five injured patients per Strasberg-Bismuth and McMahon. According to the Strasberg-Bismuth system, the majority of the injuries were Type A (3/5, 60), second Type D (1/5, 20) and Type E1 (1/5, 20). The McMahon classification showed that there were more minor injuries (3/5, 60%), but major ones were also represented (2/5 cases, 40%).

Table 3: Frequency of Strasberg-Bismuth and McMahon Classification of Common Bile Duct Injury (n = 5)

	n (%)
Strasberg-Bismuth Injury Classification	
Type A	3 (60.0%)
Type D	1 (20.0%)
Type E1	1 (20.0%)
McMahon Classification	
Major	2 (40.0%)
Minor	3 (60.0%)

Discussion

The current study found that the rate of bile duct injury (BDI) was 0.8% in patients who underwent laparoscopic cholecystectomy, which is similar to other studies that found an average of 0.3 to 0.9%. According to Viste et al. (2015) [7], the incidence was 0.5%, whereas Martin et al. (2016) [8] noted 0.7% that is also quite similar to our results. Likewise, El-Dhuwaib et al. (2016) [9] indicated an incidence of 0.8 percent, and this supports the idea that BDI is an uncommon complication of modern laparoscopy practice. These statistics are compared with the previous literature of the 1990s where the rates went up to 1.5% and it was possible to see that surgical procedures and safety measures were both improved over time (Strasberg et al., 1995; McMahon et al., 1995) [10,11]. In an 11-year population-based study, Reinsoo et al. (2022) [12] also reports a constant incidence of minor BDIs, which is in line with the present finding that most of the injuries are of a minor nature".

The demographic factors in our cohort were not significant to predict the incidence of CBD injury. The rate of injuries was also low in both younger (≤50 years) and older (>50 years) patients, and there were no differences between them in terms of gender. Such findings are consistent with the systematic review by Yang et al. (2022) [13] that has shown an age factor does not always contribute to higher BDI risk, but comorbidities can affect older age. In our study, the numerical relation was identified between obesity and BDI since all injuries were in patients with high BMI but with no statistical significance. This is not an isolated case since previous studies indicate that most excess adiposity can make surgical procedures more difficult because of poor visibility and difficult dissection (Yang et al., 2022) [13]. Conversely, Yuda Handaya et al. (2021) [14] could not determine a significant relationship of gallbladder adhesions, a risk factor that can be commonly associated with obesity, with BDI, and can indicate that obesity itself may not be sufficient to predict the risk and needs to be considered with other factors related to the procedure.

Concerning comorbidity, the renal disease became the important predictor of CBD injury in our sample. Renal pathology patients showed significantly elevated proportions of injury, possibly because tissue healing was impaired, tissue was more prone to inflammation, or intraoperative tissue treatment was different. Although the problem of renal disease is hardly mentioned as a direct risk factor by previous studies, Yang et al. (2022) identified systemic comorbidities, including diabetes, as a factor that might increase tissue fragility and inflammation, indirectly increasing the risk of injury (Yang et al., 2022) [13]. Other diseases like cholecystitis and previous laparotomy presented tendencies of higher BDI but not statistical significance in our cohort. Partially, this is in line with Mangieri et al. (2019) [6], who observed that acute inflammation and problematic anatomy may enhance the risk of BDI especially where laparoscopic surgery must be converted into open surgery.

In our study, the clinical profile of patients with CBD injuries was found to be diverse in terms of age, gender and BMI. The majority of injuries were identified afterwards with a single identification being made intraoperative, highlighting the ongoing inconvenience of early detection. This aligns with the literature that intraoperative diagnosis of BDI is still not optimal, and delayed diagnosis is one of the contributing factors toward the complications of bile leaks and cholangitis (Strasberg et al., 1995; Diaz-Martinez et al., 2020) [10,15]. The interval between first diagnosis and conclusive treatment was 10-24 days which indicated the difference in clinical decision making and symptom expression.

Injury classification showed that the minor injuries were more prevalent, with three minor injuries and two major injuries as reported by McMahon et al. (1995) [9], whereas Strasberg-Bismuth classification showed most of the injuries to be Type A. This distribution is widely in line with Diaz-Martinez et al. (2020) [15] who stated that Bismuth Type III injuries prevailed. Small injuries among our cohort were effectively treated by ERCP and stenting, but a major E1 injury was treated by surgery, which underscores the need to categorize injuries well to apply the right treatment. These management results are consistent with the reports of Kim and Donahue (2018) [1] and Khan and Ahmad (2015) [5] who focus on the use of minimum invasive interventions to treat minor injuries and surgery as the method of treatment in complex injuries.

We also find that BDI is multifactorial in nature. In spite of no significant overall incidence, risk is modulated by patient comorbidities, obesity and inflammatory states. Recent literature has highlighted the significance of the critical view of safety (CVS) in the prevention of BDI. As was said by Terho et al. (2021, 2022) [16,17], CVS and photo documentation intraoperative conditions can greatly lower the rates of injury. Gonzalez-Urquijo et al. (2022) [18] also emphasized that the complete CVS was not always achieved by residents and consultants, and continuous surgical education was the key factor in the prevention of BDI.

To conclude, we have shown that demographic factors are not necessarily predictive of BDI, but comorbidities like renal disease and obesity risk. Minor injuries are most prevalent and can be endoscopicly treated in many cases and major ones are surgically repaired. The findings are pretty consistent with the literature, but the differences in risk profiles across the studies demonstrate the

complexity of the patient-anatomical-procedural interaction in the occurrence of BDI.

Conclusion

The research proves that biliary injury in the course of laparoscopic cholecystectomy is a relatively rare yet clinically relevant complication, and the majority of cases do not depend on demographic characteristics and typical risk effects in surgery, but some comorbid conditions could predispose patients to greater susceptibility. The nature of the injuries witnessed mostly fell under the minor categories, but serious injuries were also evident which highlights the fluctuating nature and the importance of intraoperative watching. The trends in the time and mode of diagnosis showed that postoperative diagnosis was more common hence the need to carry out a comprehensive postoperative follow-up to make early diagnoses and prompt intervention. Endoscopic techniques and management strategies proved to be very successful, and complex injuries should be repaired with the help of surgery, which indicates the need of specific treatment planning. All in all, the results support the significance of careful surgical practice, timely diagnostic methods, and patient assessment based on risk factors to reduce the number of complications and maximize the results in laparoscopic cholecystectomy.

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