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Predective Factors of Common Bile Duct Injury in Laparoscopic Cholecystectomy

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ABSTRACT

Background: Laparoscopic cholecystectomy (LC) has become the preferred treatment for symptomatic gallstone disease, but advanced age and comorbidities increase the risk of complications. The incidence of bile duct injuries during LC has also increased, with various technical factors contributing to higher rates. **Aim:** This study aimed to evaluate the prevalence and predictive factors of common bile duct (CBD) injury in laparoscopic cholecystectomy. **Patients and Methods:** 850 patients with high-risk chronic diseases and specific gallbladder conditions were prospectively observed. Patients with symptomatic cholecystitis, gallstones, gallbladder polypoid lesions, and cirrhotic patients were included. Exclusion criteria involved certain conditions and contraindications. LC was performed using standard techniques, and peri-operative management followed local protocols. **Results:** The study included predominantly female participants with hypertension, diabetes mellitus and liver cirrhosis. CBD injury occurred in 5 % of cases, and it was significantly associated with cholecystitis, gallstones, gallbladder polypoid lesions, poor identification of the hepatic pedicle, technical mistakes, and difficult cases. No significant correlations were found between CBD injury and comorbidities or specific causes. **Conclusion:** CBD injury was linked to cholecystitis, gallstones, gallbladder polypoid lesions, poor hepatic pedicle identification, gallbladder inflammation, cumulative technical errors, and difficult cases. Surgeons should be vigilant during hepatic pedicle identification and dissection to avoid CBD damage. Cholecystitis, gallstones, and associated conditions need suitable treatment to ease symptoms.

Keywords: Laparoscopic Cholecystectomy, Common Bile Duct Injury, Gallstones.

INTRODUCTION

The preferred therapeutic modality for managing symptomatic gallstone disease has undergone a transformation from open cholecystectomy (OC) to laparoscopic cholecystectomy (LC) since its introduction in 1988 [(1)].

The preferred method for managing non-malignant gallbladder conditions is laparoscopic cholecystectomy (LC). A potential association has been observed between postoperative LC complications and heightened likelihood of elderly patients requiring more frequent conversion to open surgery [(2)].

The prevalence of cholelithiasis tends to rise with advancing age, with documented rates ranging from 38-53% among individuals aged 80 years and above. Elderly patients may experience a more challenging perioperative course due to the high incidence of significant comorbidities and reduced functional capacity [(3)].

Hence, the elective fatality rate of up to 2% and emergency mortality rate of 10% provide compelling evidence to exercise prudence while performing open biliary surgery on geriatric patients [(4)].

The implementation of laparoscopic cholecystectomy has resulted in enhanced patient outcomes, albeit accompanied by an increase in bile duct injury incidence as reported by a comprehensive analysis of laparoscopic cholecystectomies, which has been conducted through the examination of 78,747 cases across 98 distinct investigations [(5)].

A range of 0.36 to 0.47 percent of patients were found to have experienced bile duct damage. Technical difficulties resulting in biliary damage often arise from misidentification of anatomy and failure to detect injuries during dissection within Calot's triangle. The heightened susceptibility to notable bile duct injury during laparoscopic cholecystectomy (LC) is associated with acute cholecystitis, a technically demanding dissection, and hemorrhage. The employment of routine surgical cholangiography as a safeguard against bile duct injury is a subject of controversy [(6)].

The aim of the study was to evaluate the prevalence and predictive factors of common bile duct injury in laparoscopic cholecystectomy.

PATIENTS AND METHODS

This prospective observational cross-sectional study, included 850 patients who were selected from attendee of general surgery clinics of Liver and Minia University Hospitals. Samples were collected by the systematic random method from January 2021 to January 2024.

Inclusion criteria: We included high risk patients of chronic diseases as hypertension, DM, cirrhotic and cardiac diseases, symptomatic cholecystitis, symptomatic gallstones, asymptomatic gallstones if consent for LC, and gallbladder polypoid lesions greater than or equal to 10 mm.

Exclusion criteria: Suspected gallbladder carcinoma, cholangiolithiasis, obstructive jaundice, acute

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pancreatitis, acute cholangitis, comorbidities that contraindicate general anesthesia and LC.

Methods

All patients were subjected to: Complete history taking and complete physical examination. A laparoscopic cholecystectomy was performed using the conventional four-port approach and the French method.

The study examined the utilization of preoperative endoscopic retrograde cholangiopancreatography (ERCP) in patients presenting with abnormal liver function tests, previous gallstone pancreatitis, or common bile duct dilation (as identified through ultrasonographic imaging).

The study did not incorporate the utilization of routine intraoperative cholangiography. The attending surgeon performed clinical assessments, with the necessary support from the attending anesthetist.

Specimen histopathological assessment was done for each patient to exclude malignancy. peri-operative management for each patient was done according to local hospital protocols.

Ethical aspects:

The study protocol was approved by the Ethics Committee (Approval no.710/3/2023). Written informed consent was obtained from the patients or their legal representatives according to the patient's condition before enrollment. The consent included information about the potential consequences of the procedure and the use of the data for scientific purposes. The purpose of this study was to perform research on humans in compliance with the Declaration of Helsinki, the code of ethics of the World Medical Association.

Statistical Analysis

IBM SPSS 22.0 assessed digital data. Quantitative data were presented as mean and standard deviation (SD). Qualitative data were presented as number and percentage and were compared by Chi-Square test. Pearson correlation test will be used to correlate between two quantitative variables which were normally distributed. P values of 0.05 or less was considered significant.

RESULTS

The average age of the subjects was 44.56 years. The majority of participants were females, accounting for 68.24% of the sample. Regarding comorbidities, a significant proportion of participants had hypertension (54.12%), while diabetes mellitus was present in 45.88% of the individuals. Cholecystitis was observed in 27.1% of the patients. Additionally, 44.7% of the patients had gallstones, while cirrhosis was identified in 20% of the cases **(Table 1).**

Table (1): Demographic data of included participants

	Value (N = 850)	
Age (Years)	44.56± 13.1	
Sex	Number	Percentage
Male	270	31.76
Female	580	68.24
Comorbidities		
HTN	460	54.12
DM	390	45.88
Cardiac diseases	160	18.82
Gall bladder condition		
Cholecystitis	230	27.1
Gallstones	380	44.7
Gallbladder polypoid lesion	180	21.2
Cirrhosis	170	20

HTN , hypertensions ,DM , diabetes mellitus, number

The average fasting blood glucose level was within normal. There was a relatively normal hematological profile in the participants. The liver function tests and the electrolytes levels were within the normal range. The coagulation profile and the lipid profile also showed relatively healthy level **(Table 2**

Table (2): Lab investigations of included subjects

	Value (N = 850)
Fasting blood glucose (mg/dL)	85.13 ± 8.9
CBC	
Hgb (g/dl)	11.98 ± 0.63
WBCs (cells/µL)	10489.95 ± 1631.18
RBCs (*10^9/µL)	4.69 ± 0.36
Plt (platelets/µL)	310254.14 ± 5684.06
Liver function test	
ALT (U/L)	25.91 ± 2.29
AST (U/L)	25.45 ± 2.32
LDH (U/L)	192.5 ± 24.01
ALP (U/L)	80.09 ± 18.36
Total bilirubin (mg/dL)	2.85 ±0.38
Direct bilirubin (mg/dL)	0.52 ± 0.18
Serum electrolytes	
Na (mEq/L)	139.36 ± 1.83
K (mEq/L)	4.31 ± 0.37
Coagulation profile	
PT (s)	11.89 ± 0.67
INR	1.09 ± 0.02
Lipid profile	
TAG (mg/dL)	72.95 ± 2.33
Total cholesterol (mg/dL)	125.99 ± 30.96

CBC: complete blood count, Hgb: Hemoglobin, WBCs: white blood cells, RBCs: Red blood cell count, ALT: alanine transaminase, AST: aspartate aminotransferase, LDH: lactate dehydrogenase, ALP: Alkaline phosphatase, Na: sodium, K: potassium, PT: physical therapy, INR: international normalised ratio, TAG: topographic angiography.

Regarding the causes of CBDI, poor identification of the hepatic pedicle was the most frequently reported cause, accounting for 30.2% of the cases. Inflammatory changes in the gallbladder and anatomical anomalies were reported in 18.6% and 9.3% of cases, respectively. Cumulative technical mistakes were observed in 25.5% of cases. In terms of technical complexity 65.12% were classified as "difficult**."(Table 3).**

Table (3): Predictive factors associated with common bile duct injury

	Number =43	Percentage
Risk factors		
Obesity	7	16.3
Previous abdominal surgery	2	4.6
Cirrhosis	5	11.6
Causes		
Poor identification of hepatic pedicle	13	30.2
Inflammatory changes in the gallbladder	8	18.6
Anatomical anomalies	4	9.3
Improper use of monopolar coagulation	5	11.6
Unspecified technical mistake	4	9.3
Problem during control of intraoperative hemorrhage	2	4.6
Cumulative technical mistakes	11	25.5
Technical complexity		
• Easy	15	34.88
• Difficult	28	65.12

CBD injury group had a significantly lower prevalence of DM, cholecystitis, gallstones, gallbladder, polypoid lesions, cirrhosis, poor identification of hepatic pedicle, inflammatory changes in the gallbladder, cumulative technical mistakes, and cases categorized as difficult in terms of technical complexity when compared to the non-injured cases **(Table 4).**

Table (4): Comparison between cases with CBD injury and cases not injured regarding different parameters

		CBD injury (N = 43)	No CBD injury (N = 807)	P. Value
Comorbidities	HTN	23 (53.33%)	440 (54.5%)	0.8932
	DM	25 (58%)	308 (38.1%)	0.0089
	Cardiac diseases	10 (23.25%)	132 (16.3%)	0.2373
Gall bladder condition	Cholecystitis	24 (55.8%)	88 (10.9%)	<0.0001*
	Gallstones	35 (81.39%)	263 (23.6%)	<0.0001*
	Gallbladder polypoid lesion	22 (51%)	44 (5.45%)	<0.0001*
	Cirrhosis	20 (46.67%)	44 (5.45%)	<0.0001*
Risk factors	Obesity	7 (16.3%)	88 (10.9%)	0.2757
	Previous abdominal surgery	2 (4.6%)	15 (1.85%)	0.2025
	Cirrhosis	5 (11.6%)	15 (1.85%)	<0.0001*
Causes	Poor identification of hepatic pedicle	13 (30.2%)	132 (16.3%)	0.01842*
	Inflammatory changes in the gallbladder	8 (18.6%)	59 (7.3%)	0.00004*
	Anatomical anomalies	4 (9.3%)	59 (7.3%)	0.6271
	Improper use of monopolar coagulation	5 (11.6%)	73 (9.04%)	0.5674
	Unspecified technical mistake	4 (9.3%)	44 (5.45%)	0.2864
	Problem during control of intraoperative hemorrhage	2 (4.6%)	44 (5.45%)	0.8213
	Cumulative technical mistakes	11(25.5%)	29 (3.6%)	<0.0001*
Technical complexity	Difficult	28 (65.12%)	234 (29%)	<0.0001*

HTN: hypertension, DM: Diabetes mellitus.

CBD injury showed significant positive correlations with cholecystitis, gallstones, gallbladder polypoid lesions, poor identification of hepatic pedicle, inflammatory changes in the gallbladder, cumulative technical mistakes, and cases categorized as difficult in terms of technical complexity. However, no significant correlations were found between CBD injury and comorbidities, risk factors, or certain causes **(Table 5).**

Table (5): Correlation between CBD injury and different parameters

	CBD injury	
	r	P Value
Comorbidities		
HTN	-0.02161	0.81691
DM	0.209542	0.05472
Cardiac diseases	0.088206	0.43513
Gall bladder condition		
Cholecystitis	0.482**	<0.00001
Gallstones	0.569**	<0.00001
Gallbladder polypoid lesion	0.451**	<0.00001
Cirrhosis	0.512**	<0.00001
Risk factors		
Obesity	0.154928	0.13238
Previous abdominal surgery	0.125462	0.23218
Cirrhosis	0.045769	0.56416
Causes		
Poor identification of hepatic pedicle	0.399**	0.00007
Inflammatory changes in the gallbladder	0.442**	0.00004
Anatomical anomalies	0.175901	0.18274
Improper use of monopolar coagulation	0.075841	0.54908
Unspecified technical mistake	0.136664	0.25132
Problem during control of intraoperative hemorrhage	-0.04587	0.68353
Cumulative technical mistakes	0.628**	<0.00001
Technical complexity		
Difficult	0.552**	<0.00001

r: Pearson correlation

DISCUSSION

According to recent research conducted by **Rahman *et al.*** [7] it has been observed that laparoscopic cholecystectomy is associated with a higher incidence of bile duct injury compared to open cholecystectomy. Notwithstanding the present gold standard for managing symptomatic cholelithiasis being laparoscopic cholecystectomy.

As per the findings of **Sabet *et al.*** [8] study, bile duct injury during cholecystectomy is an iatrogenic catastrophe that is associated with significant perioperative morbidity and mortality, inferior long-term survival and quality of life, and elevated rates of subsequent litigation. Biliary tract injury may occur as a rare complication in various surgical procedures, as reported by **Strasberg** [9].

The observed prevalence of cholecystitis, gallstones, gallbladder polypoid lesions, poor identification of the hepatic pedicle, inflammatory changes in the gallbladder, cumulative technical mistakes, and cases classified as difficult in terms of technical complexity was significantly higher in the CBD injury group of our study. This discovery was made after doing a comparison examination between the group of patients that had CBD injuries and a control group that had no injuries whatsoever. According to our research, there were substantial links between CBD damage and a variety of gallbladder conditions, such as cholecystitis, gallstones, and polypoid lesions of the gallbladder. Furthermore, our data showed a significant link between CBD trauma and the appearance of cirrhosis, as well as the incorrect identification of the hepatic pedicle. CBD-induced injury has been linked to gallbladder inflammation, as well as the accumulation of technical abnormalities and technically challenging situations. The statistical significance of CBD's possible detrimental influence on comorbidities, risk factors, or specific etiologies, on the other hand, has not been shown.

Cholecystitis is an inflammatory disease of the gallbladder. The inflammatory cascade may cause a variety of morphological changes in the gallbladder, including adhesions, fibrosis, and gallbladder wall hypertrophy. The observed changes might be the result of an irritated gallbladder. Dietary changes, such as avoiding high-fat meals and drinking enough of water, may help to prevent cholecystitis. When these dietary changes are combined, the potential for synergistic benefits needs additional exploration [10].

According to the results of **Gupta *et al.*** [11] the use of certain modifications during laparoscopic cholecystectomy may provide difficulties in the dissection and identification of the common bile duct (CBD), raising the risk of CBD damage. The outcomes of this investigation were published in the peer-reviewed journal Surgery. The identification of the common bile duct (CBD) may be challenging in cases of cholecystitis, which raises the risk of iatrogenic harm occurring as a result of medical intervention. It may be difficult to distinguish the gallbladder wall from the common bile duct when cholecystitis is present because the gallbladder

may become swollen, edematous, and friable as a consequence of the inflammation caused by the condition. When the gallbladder is affected by this illness, determining the cause of the problem might be difficult because of this. It has been reported that inflammation has the ability to lead to the production of adhesions between the gallbladder and neighboring tissues. This generation of adhesions may be rather painful. In the context of surgical operations, the existence of this phenomena might possibly provide a severe impediment, hence raising the chance of negative results made by **Handaya *et al.*** [12].

Because of their ability to cause distension and inflammation of the gallbladder, cholelithiasis may commonly result in structural abnormalities. This is due to the fact that the gallbladder is stretched out. The presence of cholelithiasis during surgical procedures may lead to unforeseen harm due to possible challenges with visual acuity and discrimination of the choledochus [13].

As per the findings of **Reddy *et al.*** [14], the presence of cholelithiasis poses a challenge in identifying the choledochus, thereby elevating the likelihood of harm. The occlusion of the common bile duct by gallstones may be attributed to a potential reduction in its visibility, as suggested by **Tran *et al.*** [15]. Research findings indicate that the presence of gallstones may potentially result in the development of cholecystitis and pericholecystic inflammation.

In light of the intricate nature and heightened potential for postoperative complications, it is common practice to circumvent such issues whenever feasible [16]. **Yang *et al.*** [17] reported that the revealed risk factors for bile duct injury were abnormal preoperative liver function, acute and subacute inflammation of gallbladder, thickening of gallbladder wall (≥4 mm), cholecystolithiasis complicated with effusion, and the anatomic variations of the gallbladder triangle. However, the factors of gender and overweight (body mass index ≥ 25 kg/m^2) were not significantly correlated with bile duct injury in LC.

In the event that polypoid lesions are detected within the gallbladder during a laparoscopic cholecystectomy, it may be necessary to alter the conventional structure of the gallbladder. The aforementioned distinctions may potentially augment the technical intricacy of the therapeutic intervention. Precise surgical intervention and thorough examination of the area surrounding the common bile duct may be necessary to address these anomalies [18].

As per **Pilcher 's *et al.*** findings [19] there exists a potential risk of detrimental effects on the CBD. Polypoid lesions observed in the gallbladder are suggestive of the emergence of a novel protrusion on the inner mucosal lining of the organ. The observed lesions exhibit features that are indicative of both malignancy and benignity. As per the research conducted by **Feng *et al.*** [20] it has been observed that cancer may lead to metastasis in the common bile duct (CBD), thereby resulting in adverse health implications. Adenoma polyps, which are benign neoplasms, can be observed in the gallbladder and pose a technical obstacle to therapeutic intervention [21].

Kohn *et al.* [22] reported that patients who suffered CBDI were more likely to have had lower hemoglobin, urgent surgery, choledocholithiasis, or acutely inflamed gallbladder. Acutely inflamed conditions were risk factors for biliary injury.

According to **Mesleh and Asbun's** [23] findings, the structural characteristics of the common bile duct may require additional surgical dissection during therapeutic interventions. This discovery suggests the potential for CBD-induced harm to manifest during the surgical procedure. The hepatic pedicle serves as a conduit for the entry and exit of various hepatic structures, including the common bile duct. The anatomical location of the structure in question is situated in the inferior aspect of the hepatic organ. The anatomical site in question is situated at the inferior aspect of the hepatic organ.

As per the findings of **D'Acapito *et al.*** [24] study, inadvertent harm to the common bile duct may arise due to inadequate visualization or misinterpretation of anatomical features. Based on the results of the present study, it appears that patients who undergo laparoscopic cholecystectomy may be at an increased risk for damage to the common bile duct when compared to those who undergo traditional cholecystectomy. Challenges in accurately discerning and separating the hepatic pedicle may potentially increase procedural complexity, thereby elevating the likelihood of adverse events. Precise identification and localization of the hepatic pedicle is imperative during surgical procedures to mitigate potential harm. As per the findings of **Kapoor** [25] study, the close proximity of the hepatic pedicle and the CBD may result in potential confusion between the two anatomical structures.

Cholecystitis is a pathological condition that is typified by the presence of inflammatory alterations within the gallbladder. These changes may manifest as tissue edema, adhesions, and structural anomalies. It is plausible that the presence of cholecystitis may be causally linked to the observed alterations [26]. The observed modifications exhibited the capacity to augment the complexity of the dissection procedure, thereby elevating the likelihood of CBD dysfunction during the operative intervention [27].

In the domain of laparoscopic cholecystectomy, the recurrence of technical errors, such as erroneous identification of anatomical landmarks, utilization of unsuitable dissection techniques, or insufficient equipment manipulation, may heighten the likelihood of

CBD impairment, these inaccuracies may potentially elevate the probability of CBD harm [28].

As per the findings of **Gupta and Jain's** [29] study, the likelihood of CBD impairment escalates with the occurrence of errors, especially when they are recurrent.

In the context of laparoscopic cholecystectomy, challenging cases may present themselves with various complexities, such as pronounced inflammation, significant adhesions, anatomical variations, or other complicating factors. Challenging clinical scenarios may present supplementary impediments. Due to the technological challenges inherent in the administration of CBD, there is a possibility that the risk of adverse effects may increase as a result of these impediments, as noted by **Gupta *et al.*** [29].

CONCLUSION

Cholecystitis, gallstones, gallbladder polypoid lesions, cirrhosis, poor identification of hepatic pedicle, inflammatory changes in the gallbladder, cumulative technical mistakes, and cases categorized as difficult in terms of technical complexity were well associated with CBD injury. In the course of hepatic pedicle identification and dissection, it is advisable for surgeons to exercise a heightened degree of vigilance in order to mitigate the likelihood of CBD injury. Individuals diagnosed with cholecystitis, gallstones, or a related ailment necessitate the application of appropriate therapeutic interventions to alleviate their symptoms.

DECLARATIONS

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- **Conflicts of interest:** No conflicts of interest.
- **Competing interests:** None.

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