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Cholecystectomy associated vasculobiliary injuries: Incidence and impact on surgical repair outcomes

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ABSTRACT

Objective: Bile duct injury with concomitant vascular injury is a common complication of cholecystectomy. The influence of concomitant vascular injury on the presentation and management of bile duct injury remains debatable. This study aimed to determine the incidence of concomitant vascular injury in patients with post-cholecystectomy bile duct injury and its impact on presentation and short-term outcomes following biliary repair.

Material and Methods: This prospective study was done between November 2019 and December 2022. Patients presenting with post-cholecystectomy bile duct injury were investigated to detect vascular injury using computed tomography angiography. A comparative analysis of clinical presentation, and results of biliary reconstruction was performed on patients with and without concomitant vascular injury. McDonald criteria were used to grade the outcome of biliary reconstruction in these patients.

Results: We studied 48 patients with bile duct injury of which 19 (39%) patients had concomitant vascular injury on imaging. Concomitant vascular injury was found in 87% and 42% of patients with Strasberg type 4 and type 3 injury, respectively. At presentation, the incidence of liver abscesses was significantly higher in patients with concomitant vascular injury. After two years of biliary repair, 75% of patients had McDonald Grade A status, irrespective of whether vascular injury was present.

Conclusion: Approximately 39% of patients with biliary injury had concomitant vascular injury. A higher grade of biliary injury was associated with increased chances of concomitant vascular injury. The presence of vascular injury did not correlate with increased operative morbidity, prolonged hospital stay, or inferior outcomes of delayed biliary repair.

Keywords: Cholecystectomy, vasculobiliary injury, biloma, liver abscess, McDonald grade

INTRODUCTION

Bile duct injury (BDI) is a devastating complication of cholecystectomy. Studies suggest that between 12% and 61% of cases of BDI, particularly those involving proximal ducts, are associated with concomitant vascular injuries (1-7). Among the affected vessels, the right hepatic artery is the most commonly damaged, whereas injury to the portal vein is rare (8). The consequences of concurrent vascular injury can vary widely, ranging from asymptomatic conditions to potentially life-threatening complications (1-3). Despite standardized surgical techniques and safety measures adopted in cholecystectomy, vasculobiliary injuries (VBI) continue to occur, leading to significant morbidity and mortality (9-11).

The impact of concomitant vascular injury on the outcomes of biliary repair remains uncertain (3-7). Additionally, the appropriate timing for biliary repair in the presence of vascular injury is subject to debate (5-6,12-15). In resource-constrained settings, it is not cost-effective to routinely screen every biliary injury for concurrent vascular damage. Only a limited number of studies have prospectively investigated the incidence, presentation, and impact of concurrent vascular injury on the outcomes of biliary reconstruction.

This study aimed to determine the incidence of concomitant VBI and evaluate its impact on the outcomes of biliary repair surgery.

MATERIAL and METHODS

This prospective observational study was conducted at a tertiary-care hospital in Northern India between November 2019 and December 2022. Approval for conducting the study was obtained from the Institutional Ethics Committee of Indira

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Gandhi Institute of Medical Sciences (date: 14/12/2019, number: 1205/IEC/IGIMS/2019). Patients with documented BDI sustained during cholecystectomy were included in the study. Patients who did not undergo computed tomography (CT) angiography due to pregnancy or a contrast allergy were excluded. Additionally, patients with incidentally diagnosed gallbladder carcinoma on postoperative histopathology were excluded.

The demographic characteristics of patients, operative details of index cholecystectomy (obtained either through discharge card or telephone communication with the operating surgeon), presenting features, and details of biliary repair surgery were collected prospectively. During the study period, 61 patients with BDI were managed in our department. CT angiography to detect associated vascular injury was performed in 48 patients. These patients were enrolled in the study and were divided into two groups based on associated vascular injury on CT angiography: Patients with VBI and those with isolated bile duct injury (IBDI).

The management of patients with BDI followed standard protocol. Patients presenting with peritonitis or biloma were managed with intravenous fluids, broad-spectrum antibiotics and ultrasound-guided percutaneous drainage of collected bile. Patients presenting with cholangitis were managed with antibiotics and percutaneous transhepatic biliary drainage in selected cases.

These patients were given adequate time for resolution of biliary fistula, sepsis, and dyselectrolytemia. Any complication occurring during the follow-up was recorded. The patients were investigated for potential vascular injury and aberrant vascular anatomy, classified and they were classified according to Michel's classification (Supplementary Material 1), using CT angiography before definitive reconstruction. Preoperative magnetic resonance cholangiopancreatography (MRCP) was routinely performed to classify BDI using the Strasberg classification (Supplementary Material 2) (16). Patients were planned for delayed biliary reconstruction, usually 6-8 weeks after control of sepsis/cholangitis. The duration of injury was defined as the time from cholecystectomy to the day of repair.

Surgical Procedure: After careful adhesiolysis, a healthy segment of proximal bile duct was obtained for mucosa-to-mucosa anastomosis. Thirty-six patients underwent Roux-en-Y hepaticojejunostomy (HJ) with Hepp-Coiunaud technique using 4-0 absorbable monofilament sutures (17). Length of hospital stay was taken as the number of days after surgery.

Follow-up: Post-operative follow-up was performed every three months for a minimum of 18 months. At each follow-up, clinical examination, liver function tests, and, if required, imaging studies (ultrasound abdomen/MRCP) were done. After the last follow-up at 18 months, patients were classified according to McDonald criteria (Supplementary Material 3) to assess the operative results (18).

Statistical Analysis

Data are described in terms of range, mean ± standard deviation, frequency (number of cases), and relative frequency (percentages), as appropriate. To compare categorical data, the chi-square (χ^2) test was performed. Statistical significance was set at a p-value less than 0.05. All statistical calculations were performed using (Statistical Package for the Social Science) SPSS 21version (SPSS Inc., Chicago, IL, USA) for Microsoft Windows.

RESULTS

The study included 48 patients (36 men and 12 women) with post-cholecystectomy BDI. The median age of the patients was 41 years (range, 13-66 years). Indication for cholecystectomy was chronic calculous cholecystitis in 46 patients, whereas 2 patients were operated on for acute cholecystitis. In our study, open cholecystectomy was performed in 24 patients; 20 patients had undergone laparoscopic cholecystectomy; whereas laparoscopic cholecystectomy converted to open surgery was performed in 4 patients.

Vascular injury was detected in 19 (39%) patients, with the right hepatic artery being the most common injured vessel, followed by the middle hepatic artery injury (Figure 1a). No case of portal vein injury was observed in our study. On CT angiography, 84% (16/19) of patients with VBI had evidence of collateral formation (Figure 1b).

Five patients (10.5%) had a history of blood transfusion during the index cholecystectomy, of whom 3 (6.3%) had VBI. The duration of hospital stay following the index cholecystectomy did not show a significant difference between patients with VBI and IDBI. A hospital stay exceeding 3 days was observed in 23 (79%) patients with IDBI, in comparison to 17 (90%) in the VBI group (p=0.646). Re-exploration with peritoneal lavage and abdominal drain placement was required in 10 (21%) patients. The need for re-exploration was higher in patients with VBI than in patients with IBDI (26% vs. 17%). The demographic profile of

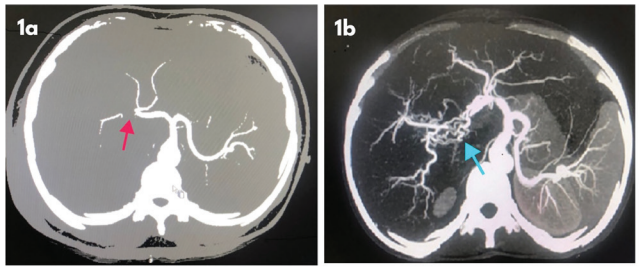

Figure 1. Computed tomography angiographic image showing (1a) showing right hepatic artery injury (red arrow), (1b) showing formation of web of collaterals after right hepatic artery injury (blue arrow).

patients, clinical presentation, and details of management have been provided in Table 1.

Overall, Strasberg type E2 BDI (48%) was seen in the majority of patients, followed by Type E3 (25%), Type E4 (17%), and Type E5 (2%). Strasberg type A injury was encountered in two patients. In our study, the incidence of vascular injury correlated with the complexity of bile duct injury. The concomitant vascular injury was present in 87% of patients with type E4 injury, whereas only 26% of patients with type E2 biliary injury had associated vascular injury (Table 2). On CT angiography, aberrant vascular anatomy was detected in six patients. Five patients had Michels' Type 3 configuration, while one patient had Michels' Type 2 configuration (19). Among patients with aberrant anatomy, only two had associated vascular injury.

The incidence of liver abscess, transaminitis, and cholangitis in the VBI and IBDI groups has been detailed in Table 3.

Four patients in our study did not undergo biliary repair surgery. Two of these patients had developed secondary biliary cirrhosis with portal hypertension by the time they presented to us and were deemed unfit for surgery. The other two patients had Strasberg type A injuries and were managed non-surgically. Biliary reconstruction was performed in 36 patients (23 patients with IBDI and 13 patients with VBI). Overall, the median interval between injury and repair was seven months (interquartile range, 5-14 months). There was no statistical significance (p=0.23) between two groups with regard to injury-to-repair duration.

In patients undergoing reconstructive surgery (n=36), five had a bile leak in the postoperative period. Three of these patients belonged to the IBDI group, while two belonged to the VBI group. In the IBDI group, one patient required multiple PCDs to control the anastomotic leak. The bile leak was managed conservatively in four other patients. A sepsis-related death occurred on post-operative day 2 in a patient with VBI.

The mean duration of hospital stay after definitive repair was 6.5±3.6 days. There was no statistically significant difference regarding the duration of hospital stay between the two groups (p=0.38) (Table 4).

Overall, patients had a mean follow-up of 26±10 months (range, 18-36 months). There was no statistically significant distinction between the two groups regarding the duration of their follow-up (p=0.14).

Table 1. Demographic and clinical characteristics of respective groups

Parameters	IBDI (29)	VBI (19)	p-value
Age (years)	41.38± 12.78	44.26± 12.92	0.66
Females: Males	21: 8	15:4	0.60
Multiple stones	20	14	0.72
Chronic cholecystitis	27	19	0.07
Acute cholecystitis	2	0	0.07
Laparoscopic approach	13	7	0.81
Open cholecystectomy	14	10	0.81
Duration of index surgery (<2 hours)	15	13	0.47
Intra operative bile duct injury detection	0	2	0.15
Blood transfusion	2	3	0.37
Hospital stay after index cholecystectomy (>3 days)	23	17	0.64
Bile leakage	15	13	0.25
Biliary stricture	14	6	0.35
Re-exploration before definitive surgery	5	5	0.12
Percutaneous drainage	16	10	0.97
Percutaneous transhepatic biliary drainage	4	5	0.27

IBDI: Isolated bile duct injury, VBI: Vasculobiliary injury

Table 2. Distribution of level of biliary injury (Strasberg-Bismuth) by surgical approach and injury type (isolated bile duct injury or vasculobiliary injury)

Biliary injury-type (Strasberg-Bismuth)	Laparoscopic cholecystectomy		Open cholecystectomy		Laparoscopic to open conversion	
	IBDI	VBI	IBDI	VBI	IBDI	VBI
Type 2	8	1	8	5	1	0
Type 3	5	3	2	2	0	0
Type 4	0	3	1	2	0	2
Type 5	0	0	0	0	1	0
Total	13	7	11	9	2	2

IBDI: Isolated bile duct injury, VBI: Vasculobiliary injury

Table 3. Comparison between IBDI and VBI with respect to complications and surgical results

Parameters	IBDI (n=29)	VBI (n=19)	p-value
Hemorrhage	2	1	0.82
Liver abscess	2	5	0.06
Cholangitis	14	10	0.76
Transaminitis	14	7	0.43
Type 2	17	6	0.11
Type 3	7	5	0.86
Type 4	1	7	0.01
Aberrant vascular anatomy	4	1	0.03
Repair within 1 year	14	9	0.40
Post operative bile leak	3	2	0.49

IBDI: Isolated bile duct injury, VBI: Vasculobiliary injury

Table 4. Follow-up of patients after biliary repair		
	IBDI (n=23)	**VBI (n=13)**
Lost to follow-up	3	2
Death	0	1
McDonald Grade A	15	8
McDonald Grade B	3	2
McDonald Grade C	1	0
McDonald Grade D	1	0
IBDI: Isolated bile duct injury, VBI: Vasculobiliary injury		

DISCUSSION

BDI is a potentially lethal complication of cholecystectomy. Concomitant vascular injury may further complicate the situation. Damage to vessels can impair blood supply to the bile ducts and liver, resulting in ischemia and tissue damage.

In the present study, concomitant vascular injury was detected in 39% of patients with bile duct injury. The most commonly involved vessel was the right hepatic artery. The incidence of VBI varies significantly across different studies, with reported rates ranging from 12% to 61%. This divergence is attributed to the selective utilization of preoperative angiography for identifying vascular injuries. Studies that incorporate routine angiography tend to report higher incidences (3,6). According to the literature, the laparoscopic approach is associated with a higher incidence of VBI compared to open cholecystectomy (6). In our study, the majority of patients underwent open cholecystectomy, which could account for the lower incidence of vascular injury (39%). Bismuth and Lazorthes (20) reported a comparable incidence of vascular injury among patients with post-open cholecystectomy bile duct injuries.

In this study, we found a correlation between the occurrence of vascular injury and the type of biliary injury. Specifically, vascular injury was detected in 87% of patients with Strasberg E4 BDI, whereas only 26% of patients with Strasberg E2 injury had associated vascular injury. Prior studies have also reported an association between the severity of biliary injury (Strasberg E3, E4) and the likelihood of concomitant arterial injury (6,12,21). In our analysis, 60% of patients with concomitant vascular injury exhibited a high type (E3 or E4) biliary injury, whereas only 40% of patients exhibited high type injury in the IBDI group. Buell et al. (12) reported a similar correlation between the incidence of arterial injury and the grade of biliary injury. In our study, a higher grade of biliary injury was more common in patients who underwent a laparoscopic procedure (n=11, 55%) than in those who underwent an open surgery (n=7, 29%). Other researchers have also observed a similar association between the laparoscopic approach and the grade of BDI (10,22).

The hepatic artery serves as a primary source of blood supply to the biliary system, and its injury may result in ischemic injury to the liver and the bile ducts. In our investigation, we observed that 26.3% of individuals with VBI developed liver abscesses, contrasting with 6.9% among those with IBDI. Among the patients who present with liver abscess (n=7): 72% (5) belonged to the VBI group. This observation is in accordance with Bilge et al. (6), who reported a 75% incidence rate of hepatic abscess in their study. However, the incidence of liver abscesses reported by Stewart et al. (21) was lower at 31% among VBI patients. The variation in the incidence of liver abscesses may be related to the grade of BDI and the interval between injury and definitive repair.

In our study, 50% (n=24) of patients had presented with episodes of cholangitis. This high incidence of cholangitis can be partly attributed to the fact that the majority of these patients underwent delayed repair. The delay in treatment was due to the Coronavirus disease-2019 pandemic, which necessitated the postponement of elective surgeries at our institute.

The impact of concomitant vascular injury on the outcomes of biliary repair remains debatable. Initially, it was reported that vascular injury could lead to a complicated postoperative course, marked by an increased incidence of anastomotic leaks, recurrent cholangitis, and anastomotic stricture formation in the long-term (4,12,23,24). However, some recent studies have shown that concomitant vascular injury does not significantly increase mortality rates or negatively impact the success of biliary repair, especially when adequate collateral circulation has been established (3,21). In our study, 36 patients underwent delayed definitive repair after resolution of sepsis and healing of biliary fistula. This approach allowed sufficient time for the injury to stabilize, and for collateral circulation to be established through the hilar vascular collaterals, which could explain the equivalent long-term results observed in the IBDI and VBI groups.

We observed a similar postoperative hospital stay in both the IDBI and VBI groups, which is consistent with the findings of Alves et al. (3). Several studies have reported higher postoperative complications and prolonged hospital stays in patients with vascular injury (6,12). Our findings could be attributed to the delayed approach that we employed in this study. The delayed surgery allowed inflammation to subside and adequate collateralization to develop, mitigating the potential complications of concomitant vascular injury.

The perioperative morbidity and mortality rates associated with the HJ procedure typically range from 20% to 35% and 1% to 4%, respectively (25,26). In our study, one patient died on the second postoperative day due to fulminant sepsis, resulting in a mortality rate of 2%. The incidence of mortality in our study aligns with the findings of Stewart et al. (21), who reported a mortality rate of 2.4%. Postoperative bile leak occurred in 5 patients (17%) in our study. Among these patients, three belonged to the IBDI group,

while two belonged to the VBI group. Our study did not identify any significant differences in terms of hospital stay or the rate of postoperative complications between the two groups.

After 18 months of biliary reconstruction, 75% of the patients had McDonald's Grade A outcome, regardless of the presence of vascular injury. At a follow-up of 26±10 months, both the VBI and IDBI groups showed excellent to good repair outcomes, ranging from 88% to 90%. In the literature, the success rate of biliary repair varies from 84% to 98% (29). In our study, collateral circulation arising from hilar shunt was observed in 84% of patients with VBI, serving as a compensatory mechanism for the injured hepatic artery. The good outcomes observed in our study, irrespective of vascular injury, could be attributed to delayed repair, which allowed healing of biliary fistula and resolution of sepsis. Additionally, some patients developed a spontaneous hepatico-duodenal fistula, providing temporary relief of symptoms (Figure 2).

Study Limitations

Our study had several limitations that should be acknowledged. Firstly, the standard technique of cholecystectomy, which includes delineating the critical view of safety, may not have been consistently employed in all cases studied. This inconsistency could have affected the incidence of vascular injury. Secondly, the experience of the primary operating surgeon was neither documented nor verified. Additionally, the higher incidence of vascular injury observed in our study population could be attributed to referral bias. It is possible that patients with more complex or severe biliary injuries, including those with concomitant vascular involvement, were preferentially referred to our institution. Consequently, the incidence of vascular injury in our study may not be representative of the general population undergoing cholecystectomy. Another important limitations of our study is the small sample size and short follow-up period, which may have restricted our ability to capture the long-term consequences of vascular biliary injury. It is important to consider these limitations when interpreting the findings of our study.

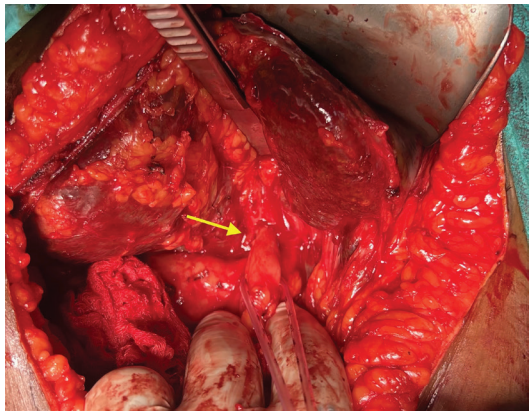

Figure 2. Intraoperative image showing spontaneous hepatico-duodenal fistula in a patient with type 3 bile duct injury.

CONCLUSION

Patients with post-cholecystectomy BDI have a high incidence of concomitant vascular injury. The laparoscopic approach is associated with complex biliary injuries and a higher likelihood of VBI compared to the open approach. The incidence of vascular injury correlates with the severity of biliary injury. Patients with VBI are more susceptible to developing hepatic abscesses than those with IBDI. Delayed Roux-en-Y HJ provided excellent functional outcomes regardless of the presence of vascular injury. In cases where delayed repair (>6 weeks) is contemplated, omitting CECT to detect concomitant vascular injury may be acceptable, as it does not alter the management plan or the surgical result.

Ethics

Ethics Committee Approval: Approval for conducting the study was obtained from the Institutional Ethics Committee of Indira Gandhi Institute of Medical Sciences (date: 14/12/2019, number: 1205/IEC/IGIMS/2019).

Informed Consent: Prospective study.

Footnotes

Author Contributions

Concept – S.S., S.K., R.K.S.; Design – S.S., M.M., San.K.; Materials – S.S., S.K., R.K.S.; Data Collection or Processing – S.S., S.K., R.K.S.; Analysis or Interpretation – M.M., S.K., R.K.S.; Literature Search – U.P., M.M., R.K.S.; Critical Review – S.S., S.K, R.K.S.; Writing - San.K., S.S., R.K.S.

Conflict of Interest: No conflict of interest was declared by the authors.

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Supplementary Material 1. Michel's classification of hepatic artery anatomical variations	
Type	
1	Normal anatomy
2	Replaced left hepatic artery from left gastric artery
3	Replaced right hepatic artery from superior mesenteric artery
4	Replaced right hepatic and left hepatic artery
5	Accessory left hepatic artery
6	Accessory right hepatic artery
7	Accessory right hepatic and left hepatic artery
8	Replaced right hepatic artery and accessory left hepatic artery or Replaced left hepatic artery and accessory right hepatic artery
9	Common hepatic artery from superior mesenteric artery
10	Common hepatic artery from left gastric artery

Supplementary Material 2. Bismuth-Strasberg classification for bile duct injury	
A	Bile leak from cystic duct or duct of Luschka
B	Occlusion of part of biliary tree, commonly a right segmental duct
C	Bile leak from divided right segmental duct
D	Lateral injury to the extrahepatic bile ducts
E	Circumferential injury of major duct
E_1	Common hepatic duct stump more than 2 cm from the confluence
E_2	Common hepatic duct stump less than 2 cm from the confluence
E3	Hilar injury with intact confluence
E4	Confluence is involved, right and left bile ducts are separated
E5	Injury of aberrant right sectoral duct with concomitant injury of main bile duct

Supplementary Material 3. McDonald's grading system for assessment of results of biliary reconstruction	
Grade A	Normal liver function test results, asymptomatic
Grade B	Mild elevation liver function test results, asymptomatic
Grade C	Abnormal liver function test results, cholangitis, pain
Grade D	Surgical revision or dilation required