

# Bile Duct Injuries Associated With Laparoscopic Cholecystectomy

## Timing of Repair and Long-term Outcomes

Ajay K. Sahajpal, MD, FRCSC; Simon C. Chow, BSc; Elijah Dixon, MD, MSc, FRCSC;  
Paul D. Greig, MD, FRCSC; Steven Gallinger, MD, MSc, FRCSC; Alice C. Wei, MD, MSc, FRCSC

**Objectives:** To report on a large experience with laparoscopic cholecystectomy–associated bile duct injuries (LC-BDIs) and examine factors influencing outcomes.

**Design:** A retrospective medical record review. Univariate statistical analysis was used to identify risk factors for postoperative complications.

**Setting:** Two university-affiliated hospitals.

**Patients:** Sixty-nine patients who underwent surgical repair of LC-BDI between January 1, 1992, and December 31, 2007.

**Main Outcome Measures:** Outcomes following repair of LC-BDI, relationship between timing of LC-BDI repair and outcomes, complications, and long-term results following LC-BDI repair.

**Results:** Thirteen immediate repairs (0-72 hours post-LC), 34 intermediate repairs (72 hours-6 weeks), and 22 late repairs (>6 weeks) were performed. The LC-BDIs were Strasberg type A in 1 patient (1%), D in 2 patients (3%), E1 in 22 patients (32%), E2 in 16 patients (23%),

E3 in 22 patients (32%), E4 in 4 patients (6%), and E5 in 2 patients (3%). Forty-one hepaticojejunostomies (59%), 24 choledochojejunostomies (35%), 3 right hepatic hepatectomies with biliary reconstruction (4%), and 1 primary common bile duct repair (1%) were performed. The overall morbidity rate was 30% (21 patients). The mortality rate was 1% (1 patient). Twelve patients (17%) developed short-term postoperative complications. There were no factors found to be associated with early postoperative morbidity. The most common long-term complication was biliary stricture, which occurred in 10 patients (14%). Patients whose BDIs were repaired in the intermediate period were more likely to develop biliary stricture than patients with repairs performed in the immediate or late periods ( $P=.03$ ).

**Conclusions:** Our results suggest that the timing of LC-BDI repair is an important determinant of long-term outcome. Repairs in the intermediate period were significantly associated with biliary stricture. Thus, repairs should be undertaken either in the immediate (0-72 hours) or delayed (>6 weeks) periods after LC.

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**Author Affiliations:** Abdominal Transplant Program and Vince Lombardi Cancer Clinic, Aurora St Luke's Medical Center, University of Wisconsin, Milwaukee, Wisconsin (Dr Sahajpal); Hepatobiliary & Pancreatic Surgical Group, Division of General Surgery, University Health Network, University of Toronto, Toronto, Ontario, Canada (Mr Chow and Drs Greig, Gallinger, and Wei); and Division of General Surgery and Surgical Oncology, University of Calgary, Calgary, Alberta, Canada (Dr Dixon).

**G**ALLSTONE DISEASE IS COMMON, affecting more than 20 million people in the United States.<sup>1</sup> As a result, more than 435 000 cholecystectomies are performed annually in the United States.<sup>2</sup> Since the early 1990s,

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laparoscopic cholecystectomy (LC) has become the standard of care for treating non-malignant diseases of the gallbladder.<sup>3</sup> Laparoscopic cholecystectomy–associated bile duct injury (LC-BDI) continues to be a clinical problem with significant morbidity for patients.<sup>4</sup> Despite a learning curve effect, there

appears to be a plateau in the rate of LC-BDI.<sup>5</sup> In the literature, the injury rate for open cholecystectomy has been estimated to be 0.2% vs approximately 0.4% to 0.6% with LC.<sup>5-7</sup>

## See Invited Critique at end of article

Bile duct injuries can range from very minor accessory duct injuries to complicated hilar injuries as described and classified by Strasberg et al.<sup>8</sup> Significant morbidity can accompany such injuries.<sup>4,9,10</sup> Late complications such as anastomotic bile duct strictures or secondary biliary cirrhosis may result in life-long disability.<sup>5</sup> Thus, these patients require multimodality care of their LC-BDIs with surgical, radiologic, and endoscopic collaboration.<sup>3,9,11</sup>

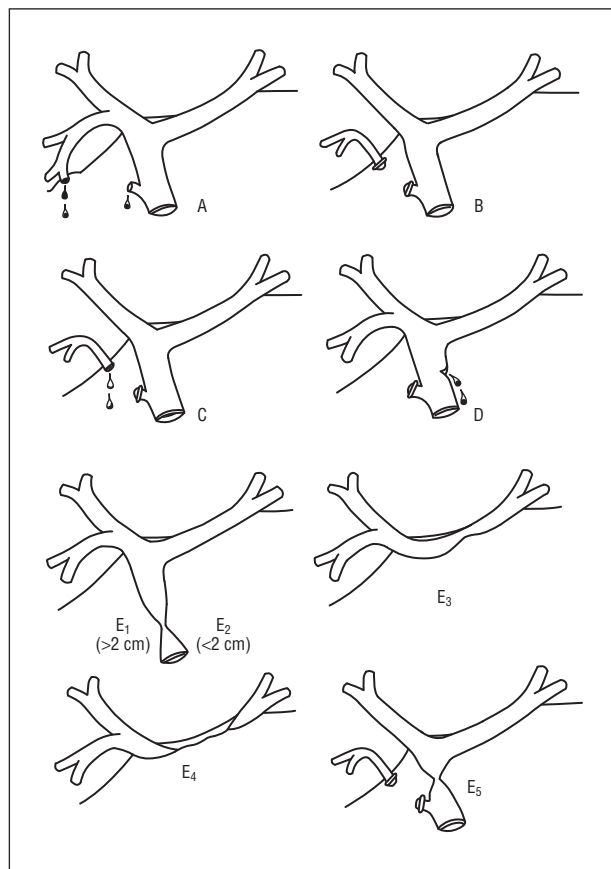


**Figure.** Strasberg-Bismuth classification of laparoscopic injuries to the biliary tract. Reproduced with permission from the *Journal of the American College of Surgeons*.<sup>8</sup>

Among hepatobiliary surgeons, debates exist regarding the optimal timing of repair after LC-BDI.<sup>12-15</sup> It is generally accepted that if an injury is identified intraoperatively, then immediate repair by a hepatobiliary surgeon is the best approach.<sup>12,13</sup> Injuries that are initially unrecognized can present days to months following LC. As a result, the optimal timing of repair is not clear.<sup>11</sup> This disparity in the timing of repair is reflected in the current literature, with different surgeons preferring different times for surgery, ie, early vs late.<sup>6,11,16</sup> de Reuver et al<sup>11</sup> and Bergman et al<sup>16</sup> prefer a later repair because they argue that an early repair has a higher risk of developing biliary stricture, whereas Schmidt et al<sup>6</sup> prefer an early repair because it decreases hospital stay, pain, and inconvenience.

The purpose of the present study was to review the results of surgical repair of LC-BDI at a major referral center. The primary outcome of this study was to describe postoperative complications of LC-BDI repair. Predictors of these complications can then be used to influence the timing of repair.

## METHODS

A retrospective medical record review of all patients referred for the surgical management of major BDIs to a tertiary care center during a 15-year period between January 1, 1992, and December 31, 2007, was performed. Repairs were performed

at 2 hospitals affiliated with the University of Toronto: the Toronto General Hospital and Mount Sinai Hospital. All patients who underwent repair surgery for LC-BDI were identified. Sixty-nine patients formed the study cohort. Perioperative data including patient demographics, operative details, perioperative data, and postoperative outcomes were extracted. Research ethics board approval was obtained from both the Toronto General Hospital and Mount Sinai Hospital.

All patients evaluated for LC-BDIs underwent preoperative investigations to evaluate biliary anatomy. In earlier years, patients underwent transabdominal ultrasonography and endoscopic retrograde cholangiopancreatography with or without percutaneous transhepatic cholangiography. In later years, computed tomography and magnetic resonance imaging were used, as required.

The anatomic extent of LC-BDIs were classified using the Strasberg-Bismuth classification system (**Figure**).<sup>8</sup> Laparoscopic cholecystectomy-associated BDIs were classified a priori into 3 groups based on timing of repair from time of injury: 1, immediate repair (0-72 hours of LC); 2, intermediate (between 72 hours and 6 weeks after LC); and 3, late (after 6 weeks). The immediate and late times were chosen when the inflammatory response was expected to be minimal. It was expected that an active inflammatory process would be present during the intermediate period.

Short-term postoperative complications were defined as those occurring within 30 days of the repair surgery or during the same hospitalization and were graded using the Dindo grade classification system.<sup>17</sup> Bile leak was defined as intraabdominal bile identified in the postoperative setting, excluding those identified intraoperatively during LC. Long-term postoperative complications were those occurring after 30 days postrepair and included bile duct strictures. Clinically significant biliary stricture was defined as a stricture that resulted in signs and symptoms requiring either surgical or percutaneous intervention. The duration of follow-up was calculated from the date of the LC-BDI repair to last follow-up visit or death. The median patient follow-up was 71.5 months, with a range of 0 to 120 months.

The SPSS statistical analysis program, version 15, was used to analyze the data. Statistical analysis was performed using the  $\chi^2$  test or Fisher exact test, as appropriate. A 2-tailed  $P \leq .05$  was considered significant.

## RESULTS

### COHORT DEMOGRAPHICS

Sixty-nine patients were reviewed (**Table 1**). There were 24 men and 45 women with a median age of 49 years at the time of repair surgery (mean, 50.2 years [SD, 16 years]; range, 12-80 years). Sixty-five patients (94%) were referred from community hospitals, 4 patients (6%) from academic hospitals. Ten patients (14%) had LC-BDIs recognized immediately at the time of LC, and 59 (86%) were diagnosed postoperatively. When BDIs presented after the LC was performed, patients presented with bile leak ( $n=33$  [48%]), jaundice (defined as having a total bilirubin serum level more than twice the upper limit of normal;  $n=31$  [45%]), and/or intraabdominal sepsis (defined as having a fever  $>38^\circ\text{C}$ , elevated white blood cell count, and abdominal pain;  $n=7$  [10%]).

Preoperative investigations included endoscopic retrograde cholangiopancreatography in 34 patients (49%),

**Table 1. Demographic Data of 69 Patients Who Underwent Repair for LC-BDI**

| Characteristic                            | No. (%)               |
|-------------------------------------------|-----------------------|
| Sex                                       |                       |
| M                                         | 24 (35)               |
| F                                         | 45 (65)               |
| Age, mean (SD), median (range), y         | 50.2 (16), 49 (12-80) |
| Site of laparoscopic cholecystectomy      |                       |
| Community hospital                        | 65 (94)               |
| Academic hospital                         | 4 (6)                 |
| Patient presentation                      |                       |
| Bile leak                                 | 33 (48)               |
| Jaundice                                  | 31 (45)               |
| Sepsis                                    | 7 (10)                |
| Time of LC-BDI presentation               |                       |
| At laparoscopic cholecystectomy           | 10 (14)               |
| Postoperative                             | 59 (86)               |
| Preoperative investigations               |                       |
| ERCP                                      | 28 (41)               |
| Transabdominal ultrasonography            | 16 (23)               |
| Computed tomography                       | 8 (12)                |
| Magnetic resonance imaging                | 6 (9)                 |
| Percutaneous transhepatic cholangiography | 22 (32)               |

Abbreviations: ERCP, endoscopic retrograde cholangiopancreatography; LC-BDI, laparoscopic cholecystectomy-associated bile duct injury.

transabdominal ultrasonography in 16 patients (23%), computed tomography in 8 patients (12%), magnetic resonance imaging in 7 patients (10%), and percutaneous transhepatic cholangiogram in 28 patients (41%). The LC-BDIs occurring in our cohort of patients were Strasberg type A in 1 patient (1%), D in 2 patients (3%), E1 in 22 patients (32%), E2 in 16 patients (23%), E3 in 22 patients (32%), E4 in 4 patients (6%), and E5 in 2 patients (3%) (**Table 2**).

#### TIMING AND TYPES OF REPAIRS

It was our institutional policy to perform LC-BDIs at the time of presentation during this study. Patients with suspected LC-BDIs were admitted and underwent preoperative assessment of their biliary anatomy and medical stabilization. If there was evidence of preoperative bile leak and/or intra-abdominal sepsis, preoperative antibiotics were administered, as appropriate. Confirmed LC-BDIs underwent urgent repair, usually within 24 hours of diagnosis.

Thirteen patients (19%) had immediate repair, 34 patients (49%) intermediate repair, and 22 patients (32%) late repair. Forty-one Roux en-Y hepaticojejunostomies (59%) and 24 choledochojejunostomies (35%) were performed. Three patients required right hepatectomies with biliary reconstruction (4%), and in 1 patient primary common bile duct repair (1%) was performed (**Table 3**). Patients who underwent repair at different periods were similar in demographic profile, with the exception of preoperative bile duct leak. When preoperative biliary leak was present, there was a statistically significant trend in favor of performing intermediate repair (Table 3). There was no difference in the complexity of LC-BDI or the type of biliary reconstruction performed during different periods (Table 3).

**Table 2. Strasberg-Bismuth Injury Classification of 69 Patients**

| Injury Classification | Description                                                               | No. (%) |
|-----------------------|---------------------------------------------------------------------------|---------|
| A                     | Leak from subvesical duct                                                 | 1 (1)   |
| B                     | Clipped and divided right segmental duct                                  | 0       |
| C                     | Divided right segmental duct                                              | 0       |
| D                     | Lateral injury common hepatic duct                                        | 2 (3)   |
| E1                    | Common hepatic duct division $\geq 2$ cm from bifurcation                 | 22 (32) |
| E2                    | Common hepatic duct division $< 2$ cm from bifurcation                    | 16 (23) |
| E3                    | Common duct division at bifurcation                                       | 22 (32) |
| E4                    | Separate left and right hepatic duct strictures                           | 4 (6)   |
| E5                    | Combined injury to main duct at bifurcation and right segmental bile duct | 2 (3)   |

#### COMPLICATIONS

The total complication rate was 30% (21 patients) in the cohort. Complications were classified according to the Dindo classification system (**Table 4**). Short-term complications occurred in 13 patients (19%). The most common was cholangitis, which occurred in 7 patients (10%). Other short-term complications included intraabdominal abscess (3 patients [4%]), wound infection (3 patients [4%]), urinary tract infection (1 patient [1%]), *Clostridium difficile* infection (2 patients [3%]), postoperative bleeding (2 patients [3%]), delirium (1 patient [1%]), pleural effusion/adult respiratory distress syndrome (1 patient [1%]), and gastrointestinal bleeding (1 patient [1%]). The mortality rate was 1% (1 patient). The patient who died was a 68-year-old woman who underwent LC for acute cholecystitis. At the time of LC, there was an LC-BDI and a concomitant main portal vein and hepatic artery injury. She had an immediate LC-BDI repair (at 36 hours), a right hepatectomy, and Roux-en-Y left hepaticojejunostomy. She died 86 days after surgery of multiorgan failure.

Long-term complications developed in 11 patients (16%). The major long-term complication was bile duct stricture, which developed in 10 patients (14%). Nine of 10 patients with strictures had repairs in the intermediate period, and the remaining patient underwent repairs in the immediate period. No patients who underwent repairs in the late period developed biliary stricture. Two patients (3%) developed incisional hernias, and there were no cases of secondary biliary cirrhosis.

#### STATISTICAL ANALYSIS

Univariate analysis using the  $\chi^2$  test and Fisher exact test was performed to determine the relationship between short-term complications and perioperative variables. Variables examined include sex, age ( $< 50$  years or  $\geq 50$  years), presence or absence of bile leak, jaundice, sepsis, more complex LC-BDIs (classes E4 and E5), type of repair, and timing of the repair (immediate, intermediate, or late). There were no associations identified between short-term postoperative complications and any of the perioperative variables examined: sex ( $P = .76$ ), age

**Table 3. Influence of Timing and Type of Repair (N=69)**

| Characteristic                                         | No. of Patients<br>by Timing of Repair <sup>a</sup> |                                 |                         | Total,<br>No.<br>(%) |
|--------------------------------------------------------|-----------------------------------------------------|---------------------------------|-------------------------|----------------------|
|                                                        | Immediate<br>(n=13<br>[19%])                        | Intermediate<br>(n=34<br>[29%]) | Late<br>(n=22<br>[32%]) |                      |
|                                                        |                                                     |                                 |                         |                      |
| Demographic Factors                                    |                                                     |                                 |                         |                      |
| Sex                                                    |                                                     |                                 |                         |                      |
| M                                                      | 5                                                   | 9                               | 10                      | 24 (35)              |
| F                                                      | 8                                                   | 25                              | 12                      | 45 (65)              |
| Age, y                                                 |                                                     |                                 |                         |                      |
| <50                                                    | 5                                                   | 18                              | 12                      | 35 (51)              |
| ≥50                                                    | 8                                                   | 16                              | 10                      | 34 (49)              |
| Site of laparoscopic<br>cholecystectomy                |                                                     |                                 |                         |                      |
| Community<br>hospital                                  | 12                                                  | 34                              | 19                      | 65 (94)              |
| Academic<br>hospital                                   | 1                                                   | 0                               | 3                       | 4 (6)                |
| Mode of presentation                                   |                                                     |                                 |                         |                      |
| Bile leak                                              |                                                     |                                 |                         |                      |
| Present <sup>b</sup>                                   | 6                                                   | 22                              | 5                       | 33 (48)              |
| Absent                                                 | 7                                                   | 12                              | 17                      | 36 (52)              |
| Jaundice                                               |                                                     |                                 |                         |                      |
| Present                                                | 4                                                   | 18                              | 9                       | 31 (45)              |
| Absent                                                 | 9                                                   | 16                              | 13                      | 38 (55)              |
| Sepsis                                                 |                                                     |                                 |                         |                      |
| Present                                                | 1                                                   | 4                               | 2                       | 7 (10)               |
| Absent                                                 | 12                                                  | 30                              | 20                      | 62 (90)              |
| Type of Repair                                         |                                                     |                                 |                         |                      |
| Primary repair                                         | 0                                                   | 1                               | 0                       | 1 (1)                |
| Roux-en-Y<br>choledochojejunostomy                     | 5                                                   | 10                              | 9                       | 24 (35)              |
| Roux-en-Y<br>hepaticojejunostomy                       | 7                                                   | 23                              | 11                      | 41 (59)              |
| Right hepatic lobectomy<br>with biliary reconstruction | 1                                                   | 0                               | 2                       | 3 (4)                |

<sup>a</sup>Repairs were classified as immediate if repaired 0 to 72 hours from laparoscopic cholecystectomy; intermediate if 72 hours to 6 weeks from laparoscopic cholecystectomy; and late if more than 6 weeks from laparoscopic cholecystectomy.

<sup>b</sup>P=.01.

(P=.13), bile leak (P=.36), hospital of origin (P=.58), jaundice (P=.22), sepsis (P=.12), complex LC-BDIs (P>.99), type of repair (P=.22), and timing of LC-BDI repair (P=.92) (**Table 5**).

Similarly, univariate analysis of the relationship between long-term complications and perioperative variables was performed. Variables examined included sex, age (< or ≥50 years), presence or absence of bile leak, jaundice, sepsis, more complex LC-BDIs (classes E4 and E5), type of repair, and timing of the repair. Risk factors for long-term complications were identified, including preoperative bile duct leak and the timing (immediate, intermediate, or late) of LC-BDI repair. There was a statistically significant relationship between the timing of LC-BDI repair and the risk of biliary strictures. Patients who underwent repairs in the intermediate period (between 72 hours and 6 weeks after LC) were at a significantly higher risk of developing biliary stricture (P=.03) compared with patients who underwent repairs either in the immediate or late periods. The presence of preoperative bile leak was also significantly associated with late

**Table 4. Dindo Classification of Postoperative Complications (n=21)**

| Grade | Description                                                                                            | Complications                                                                                 | No. (%)<br>of Patients |
|-------|--------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|------------------------|
| I     | Any deviation from the normal postoperative course and includes wound infections opened at the bedside | Delirium, leg numbness                                                                        | 2 (3)                  |
| II    | Requiring pharmacological treatment with drugs other than that allowed for grade I complications       | Cholangitis, <i>Clostridium difficile</i> infection, postoperative bleeding                   | 5 (7)                  |
| IIIa  | Requiring surgical, endoscopic, or radiological intervention not under general anesthesia              | Bile duct stricture, bile leak, cholangitis, DVT/PE, intraabdominal abscess, pleural effusion | 5 (7)                  |
| IIIb  | Requiring surgical, endoscopic, or radiological intervention under general anesthesia                  | Bile duct stricture, incisional hernia                                                        | 8 (12)                 |
| IV    | Life-threatening complication requiring intensive care unit management                                 |                                                                                               | 0                      |
| V     | Death of a patient                                                                                     |                                                                                               | 1 (1)                  |

Abbreviation: DVT/PE, deep vein thrombosis/pulmonary embolism.

biliary strictures (P=.02). Sex (P=.74), age (P>.99), hospital of origin (P=.51), jaundice (P=.74), extended biliary tract injuries (Strasberg-Bismuth classes E4 and E5, P=.24), type of repair (P=.67), and sepsis (P=.90) were not associated with the development of biliary stricture (Table 5).

## COMMENT

Despite experience gained with LC over the past decade, there are still more than 2500 LC-BDIs yearly in the United States. These injuries occur in patients who have acute or chronic inflammation that obscures normal anatomic planes in the hepatocystic triangle or when the common bile duct is anatomically misidentified.<sup>16</sup> At our center, it has been our policy to repair LC-BDI at the time of presentation without delay. In our study, we found that most LC-BDIs occur high in the biliary tree, involving the proximal extrahepatic biliary system. Sixty-eight of 69 patients required a formal biliary-enteric anastomosis for repair. There were no specific risk factors identified for short-term complications. We found that the timing of LC-BDI repair was associated with late biliary strictures. Injuries repaired in the intermediate period (between 72 hours and 6 weeks) were associated with a high rate of biliary strictures (9 of 34 [26%]) compared with immediate or late repairs.

There is consensus that these iatrogenic injuries are best handled in specialized hepatobiliary units.<sup>3,18</sup> However, the optimal time of operative repair remains controversial.<sup>11</sup> Most authors have advised repair of LC-BDI in a delayed fashion, 6 or more weeks following LC.<sup>11,16</sup> The delayed approach allows the inflammation in the right upper quadrant to subside prior to definitive reconstruction.<sup>3,6,11,16</sup> This facilitates a technically optimal repair and appears to be associated with decreased postoperative complications. Furthermore, in the early stages following an LC-BDI, there may be an unrecognized vascular injury with progression of biliary damage over time. This phenomenon may be avoided with a late repair, as the true extent of injury will declare itself by the time of repair. This idea is supported by Murr et al,<sup>19</sup> whose study revealed that the 5 patients with failure of surgical treatment shared similar characteristics: bile leaks, proximal bile duct lesions (classes E3 and E4), failed previous attempts at repair, and transanastomotic stenting. They proposed that bile leaks, perianastomotic infection, and inflammation were unfavorable conditions for immediate surgery. Ischemic ductal tissue is replaced with fibrotic scar tissue, thus explaining why early repairs can fail. Multiple other articles report a higher rate of stricture when repairs are performed in the early period (days to weeks following LC-BDI).<sup>6,11,15,19</sup>

There are also advocates for immediate repair. de Ruver et al<sup>11</sup> reported results of 151 patients who underwent repair for LC-BDI. They determined that patients who underwent repair within 6 weeks after LC-BDI had a statistically significantly higher rate of postoperative strictures ( $P=.003$ ) compared with LC-BDI repaired after 6 weeks. However, the authors did not distinguish between immediate and intermediate early LC-BDI repairs. They did report that 2 patients who underwent surgery within 2 days of laparoscopic cholecystectomy did not experience complications. Thus, despite their findings, they believe that surgical reconstruction can be performed within 2 to 3 days of the LC-BDI if there is an absence of leakage or inflammation. This idea is shared by several other authors who argue that LC-BDIs that are recognized during LC should be operated on immediately when sepsis and peritoneal contamination are absent and there is the best chance of successful outcome.<sup>10,15</sup> Thomson et al<sup>10</sup> argue that this approach is associated with cost savings, decreased morbidity, mortality, and hospital stay. This immediate approach may optimally balance the risk of postoperative problems with decreased quality of life and risk of intervening complications while awaiting surgery. Unfortunately, the definition of the optimal period for an early repair, whether it is in the initial hours or weeks following LC, is not well defined.<sup>10,11</sup> Furthermore, data that support an immediate strategy of repair is scant. Goykhman et al<sup>14</sup> have recently reported a small study of 29 patients who underwent an LC-BDI repair. They report a high stricture rate when patients undergo repair within 72 hours of the LC-BDI. They did not report on outcomes of patients who underwent repairs in the intermediate period ( $>72$  hours and before 6-8 weeks).

Interestingly, other authors have not described a relationship at all between the time of LC-BDI repair and

**Table 5. Univariate Analysis for Predictors of Short-term and Long-term Complications**

| Predictor                                 | Short-term Complications (n=12) |         | Long-term Complications (n=11) |         |
|-------------------------------------------|---------------------------------|---------|--------------------------------|---------|
|                                           | No.                             | P Value | No.                            | P Value |
| Sex                                       |                                 |         |                                |         |
| M                                         | 5                               | .76     | 3                              | .74     |
| F                                         | 8                               |         | 8                              |         |
| Age, y                                    |                                 |         |                                |         |
| <50                                       | 4                               | .13     | 6                              | >.99    |
| $\geq 50$                                 | 9                               |         | 5                              |         |
| Hospital of origin                        |                                 |         |                                |         |
| Academic                                  | 1                               | .58     | 1                              | .51     |
| Community                                 | 12                              |         | 10                             |         |
| Bile leak                                 |                                 |         |                                |         |
| Present                                   | 8                               | .36     | 9                              | .02     |
| Absent                                    | 5                               |         | 2                              |         |
| Jaundice                                  |                                 |         |                                |         |
| Present                                   | 8                               | .22     | 4                              | .74     |
| Absent                                    | 5                               |         | 7                              |         |
| Sepsis                                    |                                 |         |                                |         |
| Present                                   | 3                               | .12     | 1                              | .90     |
| Absent                                    | 10                              |         | 10                             |         |
| Strasberg LC-BDI classification           |                                 |         |                                |         |
| A-E3                                      | 12                              | >.99    | 9                              | .24     |
| E4-E5, complex                            | 1                               |         | 2                              |         |
| Type of repair                            |                                 |         |                                |         |
| Choledochojejunostomy                     | 2                               | .22     | 5                              | .67     |
| Hepaticojejunostomy and right hepatectomy | 11                              |         | 6                              |         |
| Timing                                    |                                 |         |                                |         |
| Immediate                                 | 2                               | .92     | 2                              | .03     |
| Intermediate                              | 7                               |         | 9                              |         |
| Late                                      | 4                               |         | 0                              |         |

Abbreviation: LC-BDI, laparoscopic cholecystectomy–associated bile duct injury.

complications. Sicklick et al<sup>3</sup> reported no difference in outcome between patients who underwent repair at an early ( $<1$  month after referral), intermediate (1-12 months), or delayed ( $>12$  months) time.<sup>10</sup>

In this study, we demonstrate a significant relationship between timing of LC-BDI and the long-term complication of postoperative biliary stricture. We identified 2 periods when definitive repair of an LC-BDI can be performed safely with minimal risk of late biliary strictures, either immediately ( $>72$  hours) or in the late period ( $>6$  weeks) after an LC-BDI occurs. A high rate of late postoperative biliary strictures occurred in the group of patients who underwent LC-BDI repair between 72 hours and 6 weeks.

In addition, the presence of bile leak ( $P=.02$ ) was associated with LC-BDI repairs performed in the intermediate period and long-term complications. The nature of the relationship between preoperative bile leaks, intermediate timing of repair, and long-term complications is not clear. We assume that these factors may be causally related to the development of postoperative biliary strictures.

Patients with clinically evident bile leak following LC-BDI present earlier with LC-BDI complication com-

pared with patients without clinical bile leak. Because they underwent repair at the time of presentation, this led to a greater number of patients who underwent repairs in the intermediate period. We hypothesize that the rate of biliary strictures is related to the presence of acute inflammation in the surgical bed in patients who undergo repair in the intermediate period. One contributing factor may be the increased rate of bile contamination of the peritoneal cavity in these patients. The presence of bile even in the absence of intraabdominal sepsis may result in increased acute inflammatory changes in the surgical bed.<sup>6</sup> Also, acute inflammation related to recent surgical intervention is maximal during this period of 72 hours to 6 weeks following LC. These inflammatory changes likely result in increased technical difficulties at the time of intermediate repair owing to early postoperative inflammation and tissue friability, which are characteristic of early wound healing. These inflammatory changes may predispose patients to fibrosis, resulting in a late biliary stricture.<sup>19</sup> These inflammatory changes may be absent early in LC-BDI and be minimal in immediately identified and repaired LC-BDI. In late LC-BDI repairs, the interval between LC-BDI and definitive surgery may allow resolution of the acute inflammatory response.

It is also a possibility that the technical repair performed in the intermediate period differed from repairs in the immediate or late period. In our study, it is unlikely to explain the findings reported. The same group of experienced hepatopancreatobiliary surgeons performed all LC-BDI repairs, and similar reconstructive procedures were used for all cases. In addition, anatomic severities of the LC-BDIs were comparable between patients treated at all points.

This study is a large series of surgically repaired LC-BDI. It is also one of the first studies to define a specific immediate period for LC-BDI and reports the outcomes of these immediate (0-72 hours after LC) LC-BDI repairs. One limitation of this study is our inability to perform multivariate analysis owing to the small number of adverse events of interest (ie, biliary stricture). However, our results agree with the results of other previously published articles. Given the small number of adverse effects following LC-BDI, it is unlikely that any single study will be able to fully assess the risk factors for adverse events following LC-BDI with adequate power.

The results of our data suggest that early recognition of an LC-BDI and immediate repair at a tertiary hepatobiliary center is the best approach for LC-BDIs. Immediate repair is safe and has good long-term outcomes and almost certainly is associated with shorter hospital stay and improved patient quality of life. If LC-BDIs are not identified in the immediate period, biliary reconstruction should be performed in a delayed fashion, 6 weeks or more following LC injury.

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**Correspondence:** Alice C. Wei, MD, MSc, FRCS, Hepatobiliary & Pancreatic Surgical Oncology, University Health Network, University of Toronto Division of General Surgery, 10EN-215, Toronto General Hospital, 200 Elizabeth St, Toronto, ON M5G 2C4, Canada (alice.wei@uhn.on.ca).

**Author Contributions:** *Study concept and design:* Sahajpal, Dixon, Greig, Gallinger, and Wei. *Acquisition of data:* Sahajpal, Chow, Dixon, Gallinger, and Wei. *Analysis and interpretation of data:* Sahajpal, Chow, Dixon, Gallinger, and Wei. *Drafting of the manuscript:* Sahajpal, Chow, and Wei. *Critical revision of the manuscript for important intellectual content:* Sahajpal, Dixon, Greig, Gallinger, and Wei. *Statistical analysis:* Wei. *Administrative, technical, and material support:* Dixon. *Study supervision:* Dixon, Gallinger, and Wei.

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## INVITED CRITIQUE

# Bile Leaks and Sepsis

## *Drain Now, Fix Later*

**T**his article highlights the unresolved and vexing question of the best time to repair a bile duct after a laparoscopic injury. There is consensus that the most favorable results are achieved when an experienced hepatobiliary team performs the repair. Several recent reports have suggested that in selected patients the results of early repair are as good as delayed repair with the intuitive advantages of shorter hospital stay and earlier resumption of normal activities. Once a BDI is identified, the principles of management are well defined. Effective drainage of intraabdominal sepsis, if present, and detailed cholangiographic evaluation of the biliary tree are critical as is reconstruction by a surgeon with expertise in biliary surgery.

The timing of surgical repair is dictated by the presence of sepsis and the level and magnitude of the biliary injury. A major factor bedeviling management and optimal repair is that most BDIs are not recognized during the LC and only present later, by which time the patient may be septic with infected bile collections, cholangitis, hypoalbuminemia, and jaundice. Immediate surgical repair under these circumstances is inadvisable.

The authors indicate that in their unit confirmed BDIs underwent urgent repair, usually within 24 hours of diagnosis. In their arbitrarily defined intermediate group there was a 26% postrepair stricture rate, which the authors attribute to bile leaks and perianastomotic infection, and they propose that under these circumstances ischemic ductal tissue is replaced by fibrotic scar tissue, which causes the delayed stricture. Because the implications and consequences of each bile leak vary, rang-

ing from controlled external fistulae to multiloculated infected intraabdominal collections, the timing of intervention in each situation is different. In this article the complications and grade of bile leaks and the presence of residual sepsis as detailed risk factors in patients who developed a subsequent stricture are not clearly defined. We suggest that, in patients who have large or diffuse intraperitoneal bile leaks, urgent repair within 24 hours is unwise and that all bile and infected collections first be adequately drained either percutaneously or by repeated laparoscopy. Once effective biliary drainage has been achieved, there seldom is a need for urgent repair, which can be undertaken electively and in the absence of residual sepsis.

Jake E. Krige, MB ChB, MSc, FRCS, FCS(SA)  
Philippus C. Bornman, MB ChB, FRCS, FCS(SA)  
Delawir Kahn, MB ChB, ChM, FCS(SA)

**Author Affiliations:** Department of Surgery, University of Cape Town Health Sciences Faculty, Cape Town, South Africa.

**Correspondence:** Dr Kahn, Division of General Surgery, Groote Schuur Hospital, J45 Room 23 Old Main Building, Observatory 7925, Cape Town, 7935, South Africa (delawir.kahn@uct.ac.za).

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