Intraoperative Management and Repair of Bile Duct Injuries Sustained during 10,123 Laparoscopic Cholecystectomies in a High-Volume Referral Center

Juan Pekolj, MD, PhD, FACS, Fernando A Alvarez, MD, Martin Palavecino, MD, Rodrigo Sánchez Clariá, MD, Oscar Mazza, MD, Eduardo de Santibañes, MD, PhD, FACS

BACKGROUND: Bile duct injury (BDI) remains the most serious complication of laparoscopic cholecystectomy (LC). The best strategy in terms of timing of repair is still controversial. The purpose of the current study is to review the experience in the intraoperative repair of bile duct injuries sustained during LC at a high-volume referral center.

STUDY DESIGN: Single-institution retrospective analysis of a prospectively collected database. Patients with diagnosis of BDI sustained during LC between October 1991 and November 2010 were extracted.

RESULTS: Among 10,123 LC performed during the study period, 19 patients had a BDI sustained during the procedure. Intraoperative cholangiography was routinely used. Bile duct injury was diagnosed intraoperatively in 17 patients (89.4%). Mean age was 56.4 years (range 18 to 81 years) and 15 patients were women (88%). According to the Strasberg classification of BDI, there were 3 type C lesions, 12 type D lesions, and 2 type E2 lesions. There were no associated vascular injuries. Twelve cases (71%) were converted to open surgery. The repairs included 10 primary biliary closures, 4 Roux-en-Y hepaticojejunostomies, 2 end to end anastomosis, and 1 laparoscopic transpapillary drainage. Postoperative complications occurred in 5 patients (29.4%). During the follow-up period, early biliary strictures developed in 2 patients (11.7%) and were treated by percutaneous dilation and a Roux-en-Y hepaticojejunostomy with satisfactory long-term results.

CONCLUSIONS: The current series represents one of the largest single-center experiences in terms of intraoperative repair of BDI sustained during LC. The results suggest that a high level of intraoperative diagnosis is possible, where intraoperative cholangiography is a useful tool. The intraoperative repair of BDI sustained during LC by experienced hepatobiliary surgeons either by open or laparoscopic approach appears of paramount importance to assure optimal results. (J Am Coll Surg 2013;■:1−8. © 2013 by the American College of Surgeons)

Laparoscopic cholecystectomy (LC) has become the standard surgical treatment for gallstone disease and one of the most routinely performed abdominal operations by general surgeons. Despite the known benefits of a minimally invasive surgical approach, there is still concern about the most severe complication of this procedure, the iatrogenic injury of the bile duct.[1-3] The treatment and prevention of this complication is still challenging because, in most cases, it represents a serious problem (with a mortality rate of up to 7% for complex injuries and late complications that might result in end-stage liver disease).[4]

The incidence of bile duct injuries (BDIs) seems to have decreased compared with earlier periods.[5] However, several studies showed a persistent higher rate and complexity of BDI when LC is performed compared with open procedure (0.3% to 0.6% vs 0.2%).[1,3,6,7]

Because BDI will still occur, much effort has been put toward the prevention of such injuries. Different strategies have been postulated; the critical view of safety technique and routine intraoperative cholangiography (IOC) among others, this last one with contradictory results.[1,2,8]

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From the Hepato-Pancreato-Biliary and Liver Transplant Sections, General Surgery Service, Hospital Italiano de Buenos Aires, Buenos Aires, Argentina.

Correspondence address: Juan Pekolj, MD, PhD, FACS, Hepato-Pancreato-Biliary and Liver Transplant Sections, General Surgery Service, Hospital Italiano de Buenos Aires, Juan D Perón 4190, C1181ACH, Buenos Aires, Argentina. email: juan.pekolj@hospitalitaliano.org.ar

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Abbreviations and Acronyms
BDI = bile duct injury
HPB = hepatopancreatobiliary
IOC = intraoperative cholangiography
LC = laparoscopic cholecystectomy

Once BDI has taken place, there is consensus that this complication needs to be managed at multidisciplinary centers by specialized hepatopancreatobiliary (HPB) surgeons. Often, the surgeon who does the BDI during LC has no experience in the management of this complication and additional damage or delays can occur if the inexperienced non-HPB surgeon continues to care for the patient inappropriately.[3,9]

When the BDI is diagnosed after surgery or in those patients who have received multiple previous treatments, different solutions are possible and a multidisciplinary approach is essential.[4,10-14] However, the resolution of a BDI diagnosed during the surgical procedure is purely surgical.

To date, the best management strategy in terms of timing of repair remains controversial.[3,9,15,16] Most authors agree that intraoperative recognition of BDI with immediate repair by specialized HPB surgeons offers the best results.[17] There are few reports in the literature about the results of intraoperative repair of BDI by specialist HPB surgeons.[3,16] The aim of this study was to review the results and experience in the intraoperative management of BDIs sustained during LC at a high-volume hepatobiliary referral center.

METHODS

The current report represents a single-institution retrospective analysis of a prospectively maintained LC database. Data for patients with diagnosis of BDI sustained during either routine or emergency LC at the Hospital Italiano de Buenos Aires between October 1991 and November 2010 were extracted.

The American technique of LC was used, with the patient in supine position and using 4 trocars (1 umbilical, 1 epigastric, and 2 in the right flank). Intraoperative cholangiography was used routinely in all patients. Intraoperative diagnosis of BDI was made by either direct view (bile leak or duct transection) or abnormal IOC findings. Once diagnosis was made, regardless of the experience of the primary surgeon and according to the HPB Surgery Unit policy, a member of the HPB team arrived and assisted the primary surgeon. The selection of the repair technique to be used was based on the algorithm in Figure 1. This algorithm was proposed in 2003 according to the interaction of the following variables: time of diagnosis, mechanism of injury (thermal), type of injury, and experience of the operating surgeon.[18] Simple closure was considered when there was a nonthermal partial section of a bile duct. Duct to duct anastomosis was reserved for patients with a nonthermal total or nearly total section of a bile duct, and Roux-en-Y hepaticojejunostomy was preferred for thermal lesions or biliary resections.

The follow-up of patients with LC consisted of clinical examination at 1 week, 1 month, and 1 year after surgery. Those patients with a repaired BDI were controlled every 3 months during the first year and annually afterward (with clinical evaluation and liver function laboratory tests). According to the findings, additional imaging studies were used to rule out biliary stenosis.

Patients demographics, indication for surgery, surgical opportunity (elective/emergency), type of surgery, operating surgeon, time of injury diagnosis, mechanism and type of biliary injury, predisposing (influencing) factors, IOC, surgeon that repaired the BDI, type of repair, conversion rate, postoperative complications, length of stay, early and long-term outcomes, and malpractice claims were evaluated.

The Strasberg classification[1] was used to describe the type of BDI (based on surgical and cholangiographic findings) and the Dindo-Clavien classification[19] was used to stratify the severity of complications.

RESULTS

During the 19-year study period, 10,123 consecutive LCs were performed. Nineteen patients had diagnosis of a BDI secondary to LC, representing an incidence of 0.18%. In 17 cases (89.4%), the diagnosis was performed during the surgical procedure. In the remaining 2 patients (who were discharged and readmitted at our own institution), the diagnosis was made during the postoperative period and they were therefore excluded from this study analysis.

Patient demographics

There were 15 women (88%) with a mean age of 56.4 years (range 18 to 81 years). The indication for LC was chronic symptomatic gallstones in 9 patients and acute cholecystitis in 8 patients. Three cases occurred during laparoscopic bile duct exploration. The operating surgeon was a senior HPB staff in 10 cases (59%), an HPB surgery fellow in 3 cases, a chief resident in 2 cases, and a general surgery resident in the remaining 2 cases.

The direct causes resulting in a BDI were as follows: misidentification of the anatomy in 7 patients (Fig. 2), inadequate dissection of the cystic duct in 6 patients, inappropriate technique of transcystic ductal exploration in 3 patients, and extensive dissection—skeletonization—of the bile duct in 1 patient. The contributing risk factors

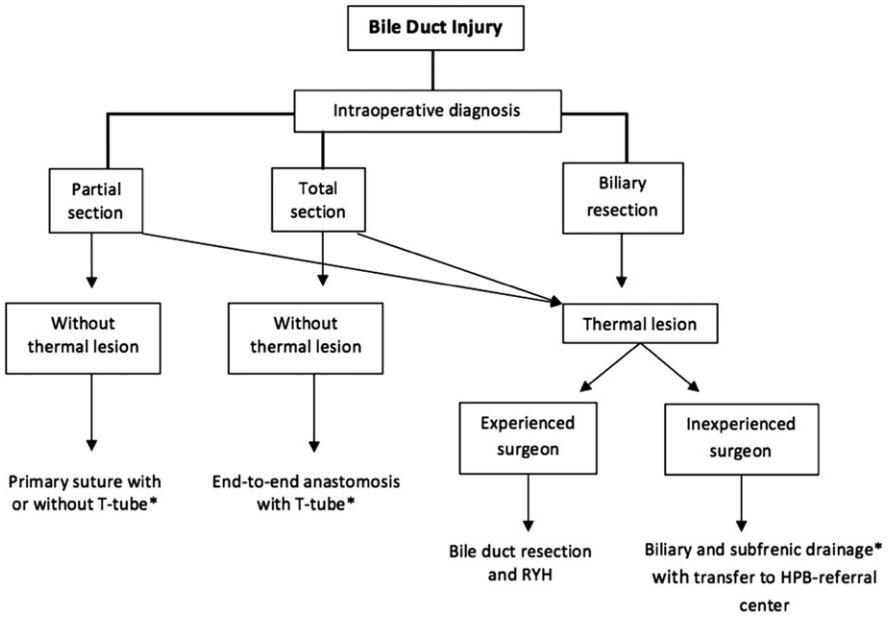

Figure 1. Intraoperative management algorithm for bile duct injuries sustained during laparoscopic cholecystectomy. *Either as an open or laparoscopic procedure. HPB, hepatopancreatobiliary; RYH, Roux-en-Y hepaticojejunostomy.

were cholecystitis in 8 patients, anatomic variations in 5 patients, inexperienced surgeon in 4 patients, Mirizzi syndrome in 3 patients, and morbid obesity in 2 patients. In 2 patients there was a thermal injury with the monopolar coagulation (hook), consisting of direct burning of the biliary tree with bile leak in 1 and a direct transection of the common hepatic duct in the other. According to the Strasberg classification of BDI, there were 3 type C lesions, 12 type D, and 2 type E2 (Fig. 2). Results of IOC in this cohort of patients are described in Figure 3.

Intraoperative management and repair

The laparoscopic procedure was converted to open in 12 (71%) patients. Elective surgery cases were converted in 55% of the patients while the emergency cases were converted in 87% of the patients.

In 5 patients (29%), the injury was repaired laparoscopically. This approach was possible because there was a limited nonthermal BDI and a surgeon with expertise in laparoscopic bile duct exploration and intracorporeal knot-suturing techniques was present. The laparoscopic repairs included 4 primary biliary closures (T-tube placement in 2, transcystic drainage in 1, and no biliary drainage in 1) and 1 laparoscopic transpapillary prosthesis (placed by the cystic duct in a patient with a perforation of the common bile duct secondary to inappropriate exploration with a Dormia wire basket). The laparoscopic technique for primary biliary closure consisted in interrupted 5-0 polidioxanone sutures with intracorporeal knot technique. At the end of the repair an IOC was performed to certify a proper repair (Fig. 4).

In those patients who were converted to open surgery, the most common procedure performed was a primary closure in 6 (5 with a T-tube placement and 1 with a transcystic drain), 4 Roux-en-Y hepaticojejunostomies (2 with the right hepatic duct only), and 2 end to end anastomosis of the right posterior duct (1 over a T-tube and 1 without biliary drainage). Patient characteristics are provided in Table 1. Mean total operative time was 188 minutes (range 135 to 300 minutes). All repairs were performed by an experienced HPB surgeon. In 13 patients (76%), the repair was performed by a different surgeon because the primary surgeon did not have sufficient expertise for the repair and/or the surgeon was emotionally compromised and preferred not to attempt the repair. Following HPB Surgery Unit policy, for the 10 patients in which an HPB staff surgeon perpetrated the injury, another HPB specialist assisted during the repair. However, in 4 of these patients, the original HPB surgeon performed the repair.

Outcomes

The outcomes of BDI managed with intraoperative repair are summarized in Table 2.

Mean length of stay after surgery was 6.3 days (range 3 to 19 days). The total complication rate was 29.4%

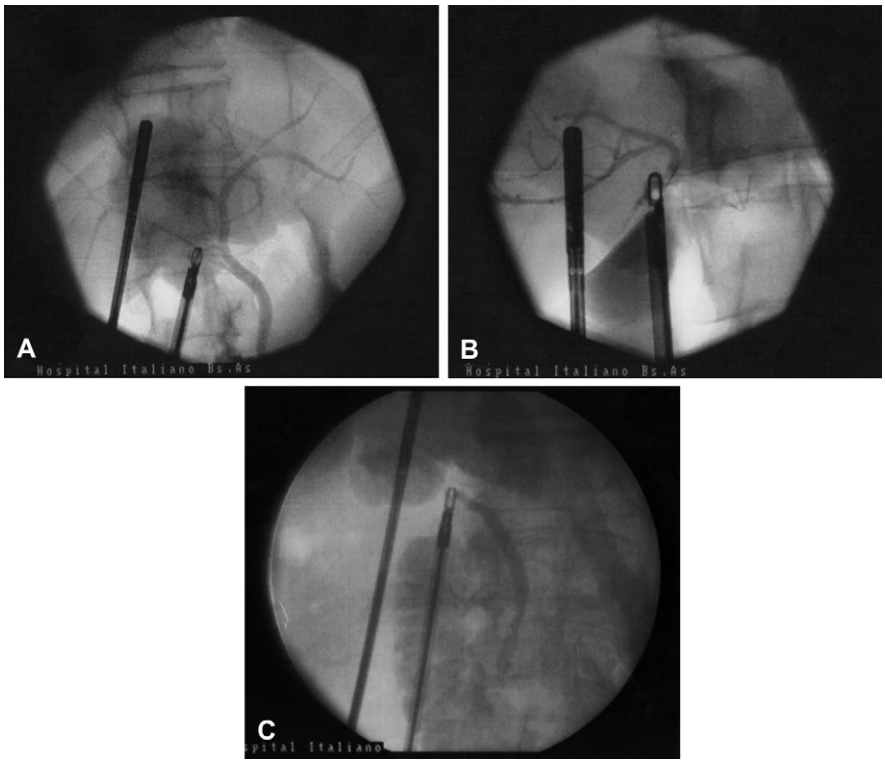

Figure 2. (A) Intraoperative cholangiography (IOC) in a 49-year-old female with cholecystitis. The anatomy of the biliary tree was erroneously considered normal. The right anterior duct was misinterpreted as the right posterior duct, which in fact was absent in the image. (B) During additional dissection in the same patient the right posterior duct was completely sectioned. A second cholangiography confirmed the Strasberg type C bile duct injury. (C) Intraoperative cholangiography that shows only the distal main bile duct (Strasberg type D injury) in a 63-year-old female with cholecystitis and a partial lateral section of the main bile duct.

(5 patients) in the cohort. Short-term complications (<30 days) occurred in 3 (18%) patients. There were 2 cases of acute pancreatitis (grade II) and a case of bile leak that required an endoscopic papillotomy (grade IIIb). Long-term (>30 days) complications developed in 2 patients (12%). Hemobilia associated with a cystic artery pseudoaneurysm (that required embolization; grade IIIb) developed in 1 patient and a bile peritonitis developed in the other patient after an accidental displacement of the T tube (the patient required laparoscopic drainage; grade IIIb).

During the follow-up period, early biliary strictures developed in 2 patients (11.7%). A Strasberg type EII stenosis developed in 1 patient (who was treated by an open primary repair of the common hepatic duct under T tube due to perforation with electrocautery) 2 months after surgery and was treated with percutaneous dilation via the T-tube tract. The second patient (who underwent a laparoscopic common bile duct closure with transcystic drainage due to partial section with scissors and extensive dissection of the main bile duct) was diagnosed 3 months after surgery with a type EII stenosis that was treated with an open Roux-en-Y hepaticojejunostomy. Both patients had a satisfactory evolution and are currently asymptomatic.

Long-term follow-up was achieved in 88% of cases (15 of 17 patients). Two patients were lost to follow-up at 4 and 5 years postoperatively and 2 patients died of unrelated causes at 2 and 12 years after surgery (glioneuromal brain tumor and stroke, respectively). All patients had successful outcomes with clinical and alkaline phosphatase controls. Mean follow-up was 71 months (range 14 to 220 months). There were no malpractice claims during the analyzed period.

DISCUSSION

Because most reports that analyze the management of BDI are from referral tertiary centers, these data are somewhat biased because this population of patients has more severe or a less well-managed BDI initially, many times with failed previous attempts of repair.[3,16,20,21] As an example, the series reported by the Johns Hopkins group,

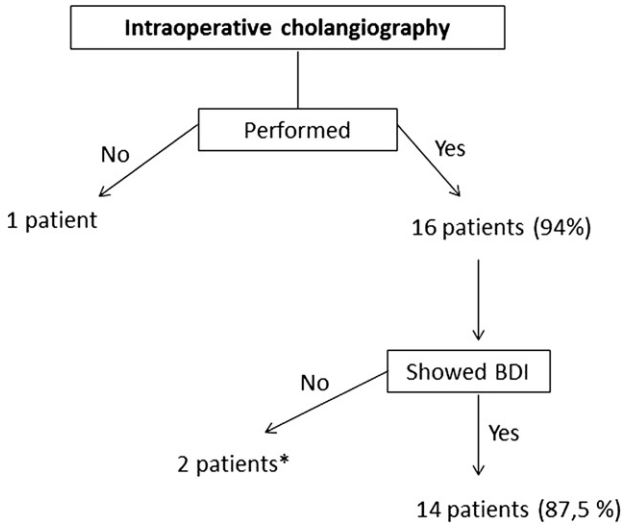

Figure 3. Results of intraoperative cholangiography in our cohort of patients. In 1 patient, the cannulation of the cystic duct was not possible due to the large inflammatory process. *In these 2 patients the bile duct injury (BDI) was not evidenced during intraoperative cholangiography due to misinterpretation of anatomical variations in the right bile ducts.

of 200 BDI repairs, only 9 lesions were repaired at the time of LC at their institution and with limited intraoperative information provided.[3]

Today, it is assumed that BDIs are complications related directly to the surgical technique and the aim is to reduce their negative impact through a low incidence, high intraoperative diagnosis, and adequate repair by trained surgeons, which could ensure long-term success.[5,17,22,23] This concept led a group in the UK to organize a specialist HPB outreach service, with surgeons traveling to the hospital where the injury is suspected and the repair is performed during the same anesthetic and surgical procedures.[17,23]

The degree of training has been shown to have a close relationship with BDI rates.[24] In the current series, our incidence of BDI was 0.18% (19 of 10,123) and in our open cholecystectomy series it was 0.19% (12 of 6,266). Most of the injuries were not serious and there were no concomitant vascular injuries. These findings do not match the classical concept of a markedly higher incidence than in open surgery.

The intraoperative diagnosis of BDI is a topic of great importance in the management of these patients because it allows lower morbidity and mortality rates. Serious postoperative complications, such as cholangitis, bilomas, or choleperitoneum are avoided; all of which are determining factors for the development of sepsis, the leading cause of mortality in these patients.[1,3,15] The rate of intraoperative diagnosis of BDI ranges between 15% and 80%, depending on the analyzed series.[17] In the current series, the diagnosis was made intraoperatively in 17 of 19 patients (89.4%). In 2 patients, we did not reach an intraoperative diagnosis, the first one was a thermal injury of the main bile duct and the other was a right posterior duct section where the interpretation of the IOC was incorrect.

Currently, there is still great controversy about the routine use of IOC. The IOC in the context of BDI has 2 main roles: diagnosis and prevention of serious injuries. Intraoperative diagnosis is the most widely accepted role, confirmed by the fact that in most of the unrecognized BDIs that are referred for treatment IOC was not performed.[24] For prevention of serious injuries such as bile duct resection, which many times start with an inadequate understanding of the regional anatomy, IOC avoids proceeding with a more severe injury. Hamad

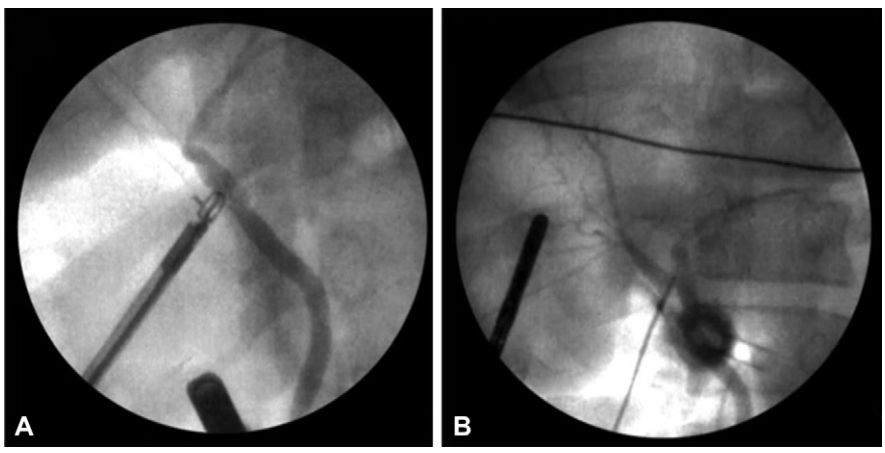

Figure 4. (A) Intraoperative cholangiography in a 53-year-old woman with symptomatic gallstone disease and a partial section of the right posterior segment bile duct. (B) Intraoperative cholangiography that demonstrates a satisfactory repair without stenosis or leaks.

Table 1. Operative Data and Overall Perioperative Outcomes in Patients with Bile Duct Injury after Laparoscopic Cholecystectomy

Patient no.	Type of surgery	Type of injury	Conversion	Type of repair	Complications	Hospital stay, d	Outcomes
1	LC + BDE	Perforation with wire basket	Yes	Primary closure*	Acute pancreatitis	19	Successful
2	LC + BDE	Perforation with wire basket	No	Transpapillary prosthesis	Acute pancreatitis	5	Successful
3	LC + BDE†	Perforation with wire basket	Yes	Primary closure*		3	Successful
4	LC	Thermal injury of choledocus	Yes	Primary closure*		4	Early stenosis
5	LC	Partial section of choledocus	No	Primary closure*		2	Successful
6	LC†	Partial section of choledocus	Yes	Primary closure*		11	Successful
7	LC	Partial section of choledocus	No	Primary closure*		4	Early stenosis
8	LC	Partial section of choledocus	No	Primary closure*	Choleperitoneum	4	Successful
9	LC†	Complete section of choledocus	Yes	RYH		8	Successful
10	LC†	Partial section of RPBD	Yes	End-to-end anastomosis*		3	Successful
11	LC†	Partial section of RPBD	No	Primary closure		4	Successful
12	LC†	Partial section of RPBD	Yes	Primary closure*	CA pseudoaneurysm	5	Successful
13	LC	Partial section of RPBD	Yes	Primary closure*		5	Successful
14	LC†	Complete section of RPBD	Yes	End-to-end anastomosis	Bile leak	10	Successful
15	LC	Right hepatic duct section	Yes	RYH		7	Successful
16	LC	Right hepatic duct section	Yes	RYH		6	Successful
17	LC†	Bile duct resection	Yes	RYH		6	Successful

*With biliary drainage.
†Emergency.
BDE, bile duct exploration; CA, cystic artery; LC, laparoscopic cholecystectomy; RPBD, right posterior bile duct; RYH, Roux-en-Y hepaticojejunostomy.

and colleagues[25] reported a 0.18% incidence of BDI in their series of 2,714 LCs without using IOC. Budding and colleagues[26] compared 2 groups of 421 and 435 patients who underwent selective or systematic IOC, respectively, and found a considerably higher rate of BDI in the first group (1.9% vs 0%), therefore, recommending the systematic use of IOC. On the contrary, Giger and colleagues[8] in a review of 31,838 patients, found no difference in the incidence of BDI (0.3% in both groups) and the inadvertent injury rate (10% vs 8%) in groups with selective or systematic IOC. In this series, IOC evidenced the BDI in 87.5% of the cases and it might have conditioned a less severe injury. In the case of biliary tract resection, IOC was performed after the BDI in a patient with a type 2 Mirizzi syndrome. In the 3 cases of main bile duct perforation with a wire basket, the early diagnosis allowed the surgeon to stop the laparoscopic bile duct exploration early.

Currently, it is accepted that a surgeon with experience in complex HPB surgery should be involved in the management and repair of BDIs. In fact, it has been postulated that a different surgeon than the one injuring the bile ducts should perform the repair; a key factor for success in cases where the original surgeon does not have expertise in the area.[27] To obtain better outcomes if the original surgeon does not have enough experience or the possibility to be immediately supported by an HPB specialist, it is advisable to place drains in the biliary tree and subhepatic area and transfer the patient to an HPB referral center.[9,16,27] On the other hand, there is less clear information about the potential negative impact or specific results of a specialist HPB surgeon at a high-volume center repairing his own injury. This is because in previously reported series, it has not been clarified whether the original HPB surgeons performed the repair or not.[3,16,28] In the current series, in 13 of 17 cases (76.4%), a different surgeon with more experience or one not emotionally involved with the case was in charge of the BDI repair. In the rest of the cases, the primary surgeon was a skilled hepatobiliary surgeon who decided to perform the repair due to its low complexity (simple closure) and because he was confident in a team environment after obtaining advice from another member of the HPB service. These patients had a favorable recovery with successful long-term results, suggesting that there was not a negative impact from this action in these selected cases.

The surgical resolution of a BDI could be performed by an open or laparoscopic approach depending of the complexity, type of injury, and level of training of the surgeon. In this series, laparoscopic repair was performed

Table 2. Type of Bile Duct Injury, Repair, and Overall Results

Characteristic	n	%
Type of injury (Strasberg-Bismuth)		
C	3	17.6
D	12	70.5
E2	2	11.7
Vascular injury	0	0
Type of repair		
Primary closure	10	58.8
End to end anastomosis	2	11.7
RYH	4	23.5
Transpapillary prosthesis	1	5.8
Complications, Dindo-Clavien grade		
II	2	11.7
IIIb	3	17.6
Length of stay, d		
Mean	6.2	
Range	2–19	
Morbidity	5	29.4
Mortality	0	0
Stenosis		
Early	2	11.7
Late	0	0
Follow-up, mo		
Mean	71	
Range	14–220	

RYH, Roux-en-Y hepaticojejunostomy.

in 29.4% of the patients. If a laparoscopic approach is chosen, the results should be at least as good as the standard open techniques.[29] It has the advantage of avoiding a laparotomy with its known potential consequences. The recognition of a thermal mechanism of injury is essential because it is the main factor in the failure of a biliary repair. The extension of thermal injuries is difficult to assess intraoperatively and becomes delimitated at late periods, so the classic recommendation is to defer treatment or to perform a resection of the biliary tree and reconstruction with a Roux-en-Y hepaticojejunostomy. When the injuries are minor, by cold mechanisms and thin biliary ducts, the recommendation is primary suture and placement of abdominal drains in the area. The reconstruction with end to end anastomosis of the main bile duct with a T tube is recommended in cases of extensive or complete sections without thermal injury. In the current series, because of the type of injuries and the mechanisms involved, the most commonly used procedure was primary suture with decompression of the biliary tract. We only performed hepaticojejunostomy in cases of bile duct resection or complete section of the right hepatic duct.

As for long-term results, recent series that describe intraoperative repair showed an impressive high rate of effectiveness ranging between 85% and 89%.[9,15,16,30] Of the 17 patients in our series who received on-table repair during surgery, 15 (88.2%) had a favorable evolution. Early biliary strictures developed in 2 patients and were re-treated satisfactorily with excellent results. Thermal injury in one patient and ischemia by devascularization in the other had direct implications on the development of stenosis.

The advantages of the intraoperative repair approach are the following: it is performed during the same anesthesia, avoids referring the patient to another institution, total hospitalization is shorter compared with delayed treatment, it generally requires few abdominal and biliary drains, and generates less psychological trauma for the patient. These events generate less discomfort to the patients and their family and are probably less likely to make malpractice litigations.[9,15,17,23,30] This topic has always been a concern among surgeons. The inappropriate management of complicated patients rather than the complication itself might be the main factor, together with an inadequate doctor–patient relationship. Preoperative information about the chance of conversion and the explanation of potential complications during informed consent is of paramount importance. The report to the family after surgery by the senior surgeon is also important. Meeting these requirements in our institution has probably helped to avoid malpractice litigation in the reported patients. In a recent publication by a Birmingham group, 67 cases of BDI and lawsuits were evaluated. The authors noted that nearly one third of patients with major transectional BDI are likely to resort to litigation. Younger patients and those in whom repair was attempted before specialist referral are more likely to initiate litigation.[30]

The characteristics of the current series differ from those usually reported, probably because it is from a high-volume HPB center where LC is performed with systematic IOC. Most of the BDIs had intraoperative diagnosis, with routine use of IOC, of low complexity and less severity, resolved with simple surgical techniques and with a satisfactory postoperative course.

The main limitation of this study is that it is based on a retrospective analysis of a small number of patients. However, to the best of our knowledge, this series represent one of the largest single-center experiences on the intraoperative repair of BDI sustained during LC.[28] In addition, this study emphasizes that it is possible to achieve very good long-term results using either open or laparoscopic techniques of repair in selected cases when performed by experienced surgeons.

CONCLUSIONS

This study demonstrates that in a high-volume HPB center, BDI meets the ideal scenario: low incidence, high rate of intraoperative diagnosis, and repair by experienced surgeons in the same surgical procedure with less complex techniques and excellent long-term results.

Author Contributions

Study conception and design: Pekolj, Alvarez, Palavecino
Acquisition of data: Pekolj, Alvarez, Palavecino
Analysis and interpretation of data: Pekolj, Alvarez, Palavecino, Sánchez Clariá, Mazza, de Santibañes
Drafting of manuscript: Pekolj, Alvarez, Palavecino, Sánchez Clariá, Mazza, de Santibañes
Critical revision: Pekolj, Alvarez, Palavecino, Sánchez Clariá, Mazza, de Santibañes

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