## **Original Research Article**

DOI: http://dx.doi.org/10.18203/2349-2902.isj20181573

# Post-cholecystectomy bile duct injuries: When to repair?

## Ayman M. A. Ali\*, Hosam F. Abdelhameed

Department of Surgery, Sohag Faculty of Medicine, Sohag, Egypt

Received: 06 April 2018 Accepted: 10 April 2018

\*Correspondence: Dr. Ayman M.A. Ali, E-mail: doc1ay@yahoo.com

**Copyright:** © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

#### **ABSTRACT**

**Background:** Post cholecystectomy bile duct injury (BDI) though rarely happens; it has its own impact on postoperative outcomes. There is controversy on the optimal time for repair of such injuries. The aim of this study was to analyze the different time modalities used for repair of these injuries and its outcomes.

**Methods:** This was a prospective randomized study conducted at General Surgery Department, Sohag university hospital, from August 2013 to March 2017. It included forty patients diagnosed to have BDI after cholecystectomy divided into 3 groups according to the time of intervention; early, intermediate, and late. We compared them regarding the pre-operative, operative variables and analyzed the post-operative outcomes among groups with one year follow-up after repair.

**Results:** Bile leakage was the main presenting symptom in 100% of patients of early intervention group while there was combination of jaundice (71.43%) and bile leakage (28.57%) in the other two groups, 28.57% of patients of intermediate intervention required ICU admission. In the early intervention group there were tendency towards less severe injuries requiring simpler maneuvers for repair with primary repairs or end to end anastomoses while in late intervention group there were tendency towards more severe injuries requiring more complex maneuvers for reconstruction. In the post-operative course there was a tendency for intermediate intervention group to have higher incidence of complications in the early and late post-operative course (57%, p=0.007). Add to this the intermediate intervention group had the longest hospital stay (p=0.008) and was plagued by mortality rate of 21% (p=0.049).

**Conclusions:** Late repair is superior to other time modalities of intervention in post-cholecystectomy BDI in terms of postoperative outcomes.

Keywords: Bile duct injury, Cholecystectomy, Outcomes, Timing of repair

## INTRODUCTION

Biliary diseases constitute a major part of digestive tract diseases, with gall bladder calculi being the commonest of them. About 80% of BDIs occur after cholecystectomy, having disastrous consequences for both the patient and the surgeon.

Add to this the cost of repair of iatrogenic BDIs is 4.5 to 26 times the cost of usual cholecystectomy.<sup>3</sup> Improper management of BDI has its own sequences ending with liver transplantation due to recurrent pyogenic

cholangitis.<sup>4,5</sup> However, a successful outcome is possible if management is applied at the proper time in a specialist center.<sup>6</sup> Studies showed that less than one third of iatrogenic BDIs are detected during LC and most of BDIs are diagnosed later on with nonspecific symptoms, such as vague abdominal pain, nausea and vomiting, and low-grade fever, secondary to intra-peritoneal leakage.<sup>7</sup>

Septicemia, jaundice or intra-abdominal abscess may occur on top. Patients who have ligation or early stricture formation may also present later on with cholangitis and obstructive jaundice.<sup>8</sup> The best treatment of BDI depends not only on the extent and location of the injury but also

the time of intervention.<sup>8</sup> The timing of surgical repair is a matter of debate, some surgeons advocate for a late repair; after 6 weeks after the insult in order to let infection, inflammation and ischemia subside before reconstruction.<sup>9</sup> In contrast, others suggest immediate repair if the BDI is recognized during primary surgery.<sup>7</sup>

The advantages of immediate repair of BDIs, when an experienced hepatobiliary surgeon is available, include single anesthesia, surgical procedure for the patient, decreases pain, better surgical outcome, shorter hospital stay, no need for referral of the patient to a tertiary center, also it decreases the need for prolonged external biliary drainage and associated increased risk of sepsis. <sup>10,11</sup> The disadvantages of such repair of BDIs are that these injuries are often complex, requiring high hepaticojejunostomy reconstruction for normal diameter (usually 3–8 mm) ducts with thin wall. <sup>10</sup>

Advocates of late repair claim that an early repair has a higher risk of developing biliary stricture also late repair allows subsidence of inflammation in the operation field prior to definitive repair. In the same time there may be an undiagnosed vascular injury with resultant bile duct ischemia and progressive biliary damage over time which may settled with a late repair, as the true extent of injury will become well established by the time of repair so investigations to exclude vascular injury to the liver should be done in all complex BDIs. 14,15

This facilitates the success of repair and is associated with fare postoperative outcomes, although late repair results in the formation of massive adhesions near the hepatic plate making repair more difficult.<sup>8</sup> Also injuries repaired in the intermediate period (between 3 days-6 weeks) are associated with a high rate of biliary strictures (26%) compared to early or late reconstruction.<sup>14</sup> The aim of the present study was to analyze the outcome of iatrogenic BDIs repair according to the different time modalities.

#### **METHODS**

This was a prospective randomized study analyzing the outcomes of post-cholecystectomy iatrogenic BDIs repair according to the time of intervention at General Surgery Department, Sohag University Hospital from August 2013 to March 2017.

Forty patients were enrolled into the study. Institutional Ethical Committee approval was taken prior to commencement of the study. A written and informed consent was taken from all patients participating in the study.

#### Inclusion criteria

 Patients with post-cholecystectomy iatrogenic BDIs both open cholecystectomy (OC) and laparoscopic cholecystectomy (LC) diagnosed intra-operative or postoperative and were not suitable for endoscopic treatment.

## Exclusion criteria

 Patients had BDIs during other operations and patients in whom the common bile duct was opened for stone extraction, patients had iatrogenic BDI and treated with ERCP, minor leaks from the gallbladder bed, patients with severe comorbidities and tumor in the gallbladder.

Patients were subjected to history and examination with special consideration to the time elapsed from the primary surgery, laboratory investigations; included complete blood picture, total and direct bilirubin, ALT, AST, Alkaline phosphatase. Abdominal ultrasonography (US), magnetic resonance cholangio-pancreatography (MRCP), some investigations have been occasionally used as CT angiography scan and percutaneous transhepatic cholangiography (PTC). The operative findings included injury classification and procedural variables, and postoperative course need for re-operation and mortality rate.

Patients were allocated into three parallel groups according to the time of BDI repair; Group A; early repair group included patients discovered and managed at time of cholecystectomy and up to 48 hours after, Group B; intermediate repair group included patients managed early postoperative from 48 hours to <6 weeks post-cholecystectomy, and Group C; late repair group included patients managed late postoperative ≥6 weeks post-cholecystectomy.

The different preoperative, operative variables and postoperative outcomes of repair were compared and analyzed among the three groups. The pathological types of bile duct injury were either complete cut of CBD, partial injury of CBD, partial injury of CHD, ligation of CBD, ligation of CHD, ligation of Rt. HD, slipped cystic duct ligature or clip, stricture of CBD, or stricture of CHD.<sup>17</sup>

The management procedure was largely related to time of diagnosis; Group (A) patients were managed by primary repair of BDI, repair over a stent, end to end anastomosis over a T-tube, bilioenteric anastomosis by Roux-en-Y hepatico-jejunostomy.

Group (B) patients were dealt with preoperative supportive measures according to the patient condition; adequate preoperative antibiotic coverage, IV fluids, parenteral vitamin K, plasma or human albumin. Patients with biliary peritonitis were managed by laparotomy with peritoneal lavage and drainage of abdominal collection, also percutaneous drainage under US guidance was done in some patients.

Intraoperative surgical repair by different modalities as primary repair of bile duct injury, repair over a stent, end to end anastomosis over T-tube, bypass surgery by Rouxen-Y hepaticojejunostomy. Group (C) patients; after preoperative evaluation and preparation the most accepted choice surgically was Roux-en-Y hepaticojejunostomy.

The postoperative follow-up included the early outcome measures; wound infection, post-operative bile leakage, normalization of bilirubin (days), need for re-operation, complication rate, and length of hospital stay were registered and analyzed. T-tube cholangiography was done 10 days postoperatively. US were done to patients following hepatico-jejunostomy to ensure absence of leakage or any abdominal or pelvic collection.

The late outcome measures included diagnosis of stricture formation, incisional hernia, and mortality rate. Patients were followed up for one year. The follow-up period ended on March 2018.

## Statistical analysis

Data were analyzed using STATA intercooled version 12.1 (Stata Corp., College Station, TX). Quantitative data

were represented as mean, standard deviation, median and range. Data were analyzed using ANOVA for comparison of the means of the three groups. When the data was not normally distributed Kruskal Wallis test was used. Qualitative data was presented as number and percentage and compared using Chi-square test. P value was considered significant if it was <0.05.

#### **RESULTS**

The study included 40 patients suffered from iatrogenic BDIs; 29 patients (72.5%) underwent OC, and 11 patients (27.5%) underwent LC. They were referred from other hospitals to the General Surgery department in Sohag University Hospital except 10 patients. There were 27 females (67.50%), 13 males (32.50%) with a female to male sex ratio equals 2.1:1. There was no significant difference among groups regarding patient's sex; p=0.10. The mean age of the study groups was 39.53±(11.85) and median 39 (20-60). This variable was significant among groups with a tendency of Group (C) to have older patients; P <0.05. Comorbidities were documented in 4 patients (33%) of Group (A), 5 patients (36%) of Group (B), and 9 patients (64%) of Group (C). This difference was not significant among the study groups; p=0.15. Further distribution of the different comorbidities is shown in Table 1.

Variable Group (A) N=12 **Group (B) N=14 Group (C) N=14** P value Age / year 32.83 (8.21) 39.43 (14.49) 45.36 (8.72) Mean (SD) 0.02 Median (range) 37 (21-44) 41 (20-60) 44.5 (32-58) Gender Females 11 (91.67%) 8 (57.14%) 8 (57.14%) 0.10 Males 6 (42.86%) 1 (8.33%) 6 (42.86%) BMI Mean (SD) 27.82 (5.16) 34.26 (3.42) 23.45 (3.57) < 0.001 Median (range) 26.17 (20.55-35.65) 34.15 (27.66-40.39) 23.41 (18.43-29.78) History of medical problems 8 (66.67%) 9 (64.29%) 5 (35.71%) No Diabetic 4 (28.57%) 1 (8.33%) Diabetic and hypertensive 2 (14.29%) 1 (7.14%) 0.15 Hypertensive 3 (25.00%) 3 (21.43%) 2 (14.29%) Ischemic heart 2 (14.29%)

Table 1: Demographic criteria.

Bile leakage was the main presentation in Group (A) patients (100%), while obstructive jaundice was the main presentation in Group (B) patients 71.43% and Group (C) patients 71.43% and this was statistically significant among groups;  $p \le 0.001$  (Table 2).

The laboratory findings of Group (B) patients showed that they had the highest WBC values, and this difference was a significant one; p=0.001. While Group (C) had the

highest bilirubin level both total and direct and this difference was a significant among groups; p=0.001.

This raised bilirubin level was the main biochemical derangement and was important in both the diagnosis and postoperative follow-up. Also, Group (B) had the highest AST and ALT in comparison with the other groups and this difference was a significant one with p=0.002 and p=0.03 respectively (Table 2).

Of the 40 patients included in the study 6 patients (15%) were diagnosed by the presence of bile in the operating field and the injury can be detected, and the other 34 patients (85%) were subjected to further investigations; US, CT, CT angiography, and MRCP for diagnostic purposes (Table 2). According to the time of intervention Group (A) included 12 patients (30%), Group (B) included 14 patients (35%), and Group (C) included 14 patients (35%).

All patients of Group (A) were presented with bile leak, while most of the patients in Group (B) and Group (C) were presented with obstructive jaundice. The delay in injury diagnosis accounted for 70% of patients who underwent intermediate repair; Group (B) 35%, and late repair; Group (C) 35% (Table 2).

Table 2: Clinical presentation and preoperative investigations.

Variable	Group (A) N=12	Group (B) N=14	Group (C) N=14	P value
Reasons for intervention				
Abdominal collection	0	4 (28.57%)	4 (28.57%)	
Bile b leakage	12 (100%)	0	0	< 0.001
Obstructive jaundice	0	10 (71.43%)	10 (71.43%)	<0.001
Methods of diagnosis				
Bile in the field	6 (50.00%)	0	0	
Detection of injury (intraoperative)	6 (50.00%)	0	0	
Abdominal US	6 (50.00%)	10 (71.43%)	8 (57.14%)	
CT abdomen	0	1 (7.14%)	1 (7.14%)	< 0.001
MRCP	6 (50.00%)	13 (21.43%)	5 (35.71%)	
Hemoglobin				
Mean (SD)	9.64 (1.41)	10.51 (1.79)	11.32 (1.60)	0.04
Median (range)	9.57 (7.97-12.07)	9.98 (8.23-14.23)	11.8 (8-14)	0.04
WBCs				
Mean (SD)	8542 (3001)	13742(2495)	6521 (3245)	< 0.001
Median (range)	8142 (5392-14392)	13987 (9028-18722)	5671 (2821-13421)	
Total bilirubin				
Mean (SD)	1.08 (0.25)	4.32 (2.09)	5.71 (2.98)	< 0.001
Median (range)	1 (0.8-1.5)	5 (0.8-7)	6.25 (1-11)	<0.001
Direct bilirubin				_
Mean (SD)	0.38 (0.31)	3.44 (1.92)	4.9 (2.67)	< 0.001
Median (range)	0.2 (0.2-1)	4 (0.2-6.5)	5.5 (0.2-9)	<0.001
AST				
Mean (SD)	50.65 (14.41)	74 (24.71)	39 (19.66)	0.002
Median (range)	50.32 (29-77)	72 (40-123)	42 (5-68)	0.002
ALT				
Mean (SD)	75 (16.84)	90 (22.46)	64 (16.14)	0.03
Median (range)	63 (24-85)	78 (37-112)	72 (30-95)	0.03

The distribution of BDIs according to Tantia classification were as following; the most common findings in Group (A) patients were partial injury to CBD while main findings in Group (C) were stricture of CBD 21.43% or CHD 78.57%. The findings in Group (B) patients were variable. These findings were significant among groups; p<0.05.

There was a significant difference in the complexity of BDI during different periods being more complex in Group (B) and Group (C) rather than group (A); p<0.001 and accordingly the magnitude and type of biliary reconstruction performed also more technically demanding for both groups; B and C, p<0.001 (Table 3).

In the post-operative follow-up bile leakage was evident more in Group (B) than other groups; p= 0.001, with a need for intervention also more in this group; p= 0.02. Also, hospital stay, normalization of liver functions, normalization of total, direct bilirubin and outcome has a significant p value <0.05 in favor of Group (A) (Table 4).

Table 3: Clinical presentation and preoperative investigations.

Intraoperative findings	Group (A) N=12	Group (B) N=14	Group (C) N=14	P value
Grade of bile duct injury				
Complete cut of CBD	2 (16.67%)	1 (7.14%)	0	
Partial injury of CBD	8 (66.66%)	4 (28.57%)	0	
Partial injury of CHD	2 (16.67%)	0	0	< 0.001
Ligation of CBD	0	6 (42.86%)	0	
Ligation of CHD	0	2 (14.29%)	0	
Ligation of Rt. HD	0	0	0	
Slipped cystic duct ligature or clip?	0	1 (7.14%)	0	
Stricture of CBD	0	0	3 (21.43%)	
Stricture of CHD	0	0	11 (78.57%)	
Procedure performed				
1ry repair of CBD	7 (58.33%)	2 (14.29%)	0	
Choledocojejunostomy	0	0	3 (21.43%)	< 0.001
Hepaticojejunostomy Roux-en-Y	2 (16.67%)	9 (64.28%)	11 (78.57%)	_
Securing the cystic duct	0	1 (7.14%)	0	
Repair over a stent	0	0	0	_
Repair over T- tube	3 (25.00%)	2 (14.29%)	0	

The total complication rate was 33% (13 patients) in the study population, distributed as 3 patients (25%) in Group (A), 8 patients (57.14%) in Group (B), and 2 patients (14.29%) in Group (C) with p=0.007. Wound infection occurred in 5 (12.5%) patients; one patient in Group (A) and 4 patients in Group (B), responded well to

regular daily dressings, this variable was a significant; p=0.001 with more infection in Group (B). The main long-term complication was the post-operative stricture formation which happened in 5 patients (12.5%) distributed as 1 patient (8.33%) in Group (A) and the other 4 patients (28.57%) in Group (B).

Table 4: Post-operative follow-up of studied population.

Postoperative findings	Group (A) N=12	Group (B) N=14	Group (C) N=14	P value
Post-op bile leakage	1 (8.33%)	4 (28.57%)	2 (14.29%)	0.001
Normalization of Bilirubin (days)				
Mean (SD)	1.06 (1.16)	3.14 (1.03)	7.07 (0.73)	0.07
Median (range)	1 (0.5-1.3)	3 (2-5)	7(6-8)	_
Need for re-operation	0	4 (28.57%)	0	0.02
Wound infection	1 (8.33%)	4 (28.57%)	0	0.153
Incisional Hernia	0	3 (21.42%)	1 (7.14%)	0.123
Need for ICU admission	0	4 (28.57%)	0	0.02
Hospital stay				
Mean (SD)	3.58 (1.37)	7.79 (1.67)	4.57 (1.28)	0.008
Median (range)	3 (2-7)	7.5 (5-10)	4 (3-7)	
Bile duct stricture	1 (8.33%)	4 (28.57%)	0	0.001
Complication rate	3 (25.00%)	8 (57.14%)	2 (14.29%)	0.007
Mortality rate	0	3 (21.42%)	0	0.049

This variable was statistically significant p<0.001. Better results are seen in Group (C) patients than Group (B) patients.

The overall mortality rate was 8% (3 patients) out of 14 patients in Group (B), 11 patients (78.57%) recovered without any complication and followed-up for one year

without any complaint. This variable was statistically non significant among groups p=0.049 (Table 4). Regarding the hospital stay, it was significantly longer in Group (B); p=0.008.

Add to this the ICU stay was also confined to patients of Group (B) p=0.2 which adds to the total cost and hence in

favor of early or late repair rather than intermediate repair.

#### **DISCUSSION**

Since the first LC in the 1990s, BDI incidence became double folded from 0.2% to 0.4% and remained stationary despite advances in knowledge, technique, and technology. Also, the injuries become more compound. Cholecystectomy is responsible for 80% of iatrogenic BDI and because it is done frequently as 10-15% of adult gallbladders in developed countries contain calculi, it is expected that iatrogenic BDI won't decrease. One of the important issues in dealing with the problem is the decision of the surgeon when to reconstruct.

The age and gender of the patients in the present study were in accordance with the others which may be due to the preponderance of biliary diseases in females in this age group and accordingly morbidities of the biliary surgery are also seen in females.<sup>22,23</sup> There was a tendency of Group (C) to have older patients than other groups of the study. We found that the incidence of BDI was significantly affected by the advance of age and the increase of the body weight as a comorbidity factor which is in line with the others.<sup>24</sup>

In the present study 72.5% of the BDIs happened after OC also the injuries were less complex than those seen after LC that does not mean that OC has higher risk of BDI but this was because LC are less performed in the areas from where the patients were referred.

BDI may evoke itself by either biliary leak or biliary obstruction, or sometimes both. Accompanying vascular injuries are found in 7 to 32% of patients. The timing of repair may be early or delayed according to the time of discovery of the injury whether intraoperative or later on. In our series the early repair included 30% of the study group which is in accordance with the others that is because most of the patients are referred from other hospitals. This is in line with Jarnagin and Blumgart who mentioned that some injuries cause partial obstruction which depends mainly on the degree of CBD entangled in the clip. 27,28

Bile leakage after the primary surgery may induce vague symptoms, like abdominal fullness, distension, nausea, vomiting, fever and chills and finally abdominal pain. So patients who fail to recover after discharge or develop progressive vague abdominal symptoms should be evaluated for a BDI.<sup>29</sup> They should have alkaline phosphatase estimation since it is the most sensitive test to diagnose obstructive biliary disease.<sup>23</sup> If unrecognized, biliary leak may lead to bilomas, fistulas, cholangitis, sepsis, or even to multiple organ failure.<sup>7</sup>

Bile duct obstruction without leak may cause only mild symptoms, which may subside and return later on as cholangitis, obstructive jaundice, and secondary biliary cirrhosis.<sup>30</sup>

For diagnosis of BDI, the used imaging tools were US, CT, MRCP, ERCP and PTC. With US, dilated intrahepatic and extrahepatic bile ducts can be diagnosed in addition to abdominal fluid accumulation, abscesses, and biloma if present. CT is more specific in patients with suspected bile leak, it detects possible vascular or liver parenchymal lesions.<sup>29</sup> PTC is more useful in patients with proximal BDI. MRCP can identify clearly the anatomy of the biliary tract which may be difficult to delineate during surgery.31 The advantage of MRCP is to define the anatomy of all ducts, even those that are not in continuity with the biliary system.<sup>32</sup> The best diagnostic tool of a stricture of bile duct and its exact extent is by MRCP and PTC. MRCP has a place also in patients with contrast allergies. ERCP is safe but less effective than MRCP as it shows only the duct below the stricture, also there should be continuity of the extrahepatic duct to the duodenum.<sup>33</sup> It should be performed in all patients before surgery, and in the case of continuity with the duodenum, ERCP should be performed. It shows the distal duct stenoses33 and it is also therapeutic.34 Data of ERCP were ignored as the cases diagnosed and managed by ERCP (non-surgical) were excluded from the present study.

We found that raised serum bilirubin and its direct fraction levels were the main biochemical derangements and are very important for both diagnosis and postoperative follow-up.

The best management strategy according to timing of repair remains controversial, most authors agree that intraoperative diagnosis of BDI with immediate repair by specialized surgeons offers the best chance. 14,35 The advantages of early repair are the avoidance of sepsis and a shorter recovery and hospitalization stay, with shorter off work vacations. However, the following criteria need to be fulfilled; no associated vascular injury, the patient is fit for a lengthy maneuver, absence of intra-peritoneal sepsis and severe local inflammation, repair is performed by an experienced surgeon, and the biliary injury and anatomy must be clearly delineated with identification of all the relevant segmental/sectoral bile ducts involved in repair. But there are situations in which a primary biliary repair is not applicable, for example, when there is excessive thermal injury with difficulty in determination of the extent of the lesion, where excessive inflammation does not allow tension free repair, in such cases it is advised to place a suture or clip to induce intrahepatic biliary dilatation, making it more suitable for a delayed biliary repair. But this is not allowed before verification that the drained biliary sector is limited by this channel.<sup>36</sup>

According to our results, when early repair is missed and intermediate repair is undertaken a higher complication rate happened in 57% of patients and treatment failure in 29% of patients, this was in accordance with the others.<sup>14</sup>

Add to this, there were an overall mortality of 21.43% in patients experienced this repair, while there were no deaths in other groups, this may be due to delayed diagnosis and referral, this figure is higher than that reported in previous studies12 which may be due to the small number of patients.<sup>12</sup> So, this kind of repair is not advised.

Delayed repair is advised in bacterial peritonitis or local inflammation, the patient's general condition should be corrected with adequate drainage of bile by using percutaneous drainage, PTC and ERCP with stenting. Infection has to be treated and maintenance of good nutritional status is also necessary which usually takes a matter of 8 to 12 weeks.<sup>29</sup> In the case of an associated injury to the right hepatic artery, a waiting period permits the bile duct to atrophy back to perform an anastomosis with healthy bile duct tissue, thereby minimizing the possibility of a post-operative anastomotic stricture.<sup>15</sup>

According to the current results delayed repair is superior to the intermediate repair with its bad outcomes. Still immediate repair looks well but in presence of skilled surgeon and in a tertiary center with the availability of equipment and the multidisciplinary work.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the

Institutional Ethics Committee

#### **REFERENCES**

- 1. Anand A, Pathania B.S., Singh G. Conversion in laparoscopic cholecystectomy: An evaluation study. JK Sci. 2007;9(4):171-4.
- Lau WY, Lai EC, Lau SH. Management of bile duct injury after laparoscopic cholecystectomy: a review. ANZ J Surg. 2010;80(1-2):75-81.
- 3. Savader SJ, Lillemoe KD, Prescott CA, Winick AB, Venbrux AC, Lund GB, et al. Laparoscopic cholecystectomy-related bile duct injuries: a health and financial disaster. Ann Surg. 1997;225(3):268-73.
- 4. Loinaz C, González EM, Jiménez C, Garcīa I, Gómez R, González-Pinto I, et al. Long-term biliary complications after liver surgery leading to liver transplantation. Word J Surg. 2001;25(10):1260-3.
- de Santibaés E, Ardiles V, Gadano A, Palavecino M, Pekolj J, Ciardullo M. Liver transplantation: the last measure in the treatment of bile duct injuries. World J Surg. 2008;32(8):1714-21.
- Shah SR, Mirza DF, Afonso R, Mayer AD, McMaster P, Buckels JA. Changing referral pattern of biliary injuries sustained during laparoscopic cholecystectomy. Br J Surg. 2000;87(7):890-1.
- 7. Sicklick JK, Camp MS, Lillemoe KD, Melton GB, Yeo CJ, Campbell KA, et al. Surgical management of bile duct injuries sustained during laparoscopic

- cholecystectomy: perioperative results in 200 patients. Ann Surg. 2005;241(5):786-95.
- 8. McPartland KJ, Pomposelli JJ. Iatrogenic Biliary Injuries: Classification, identification, and management. Surg Clin North Am. 2008;88(6):1329-43.
- Lillemoe KD. Current management of bile duct injury. Br J Surg. 2008;95(4):403-5.
- Salama IA, Shoreem HA, Saleh SM, Hegazy O, Housseni M, Abbasy M, et al., Iatrogenic Biliary Injuries: Multidisciplinary Management in a Major Tertiary Referral Center. HPB Surg. 2014;2014;575136.
- 11. Schmidt SC, Langrehr JM, Hintze RE, Neuhaus P. Long-term results and risk factors influencing outcome of major bile duct injuries following cholecystectomy. Br J Surg. 2005;92(1):76-82.
- 12. de Reuver PR, Grossmann I, Busch OR, Obertop H, van Gulik TM, Gouma DJ. Referral pattern and timing of repair are risk factors for complications after reconstructive surgery for bile duct injury. Ann Surg. 2007;245(5):763-70.
- 13. Bergman JJ, Van den Brink GR, Rauws EA, De Wit L, Obertop H, Huibregtse K, et al. Treatment of bile duct lesions after laparoscopic cholecystectomy. Gut. 1996;38:141-147.
- 14. Sahajpal AK, Chow SC, Dixon E, Greig PD, Gallinger S, Wei AC. Bile duct injuries associated with laparoscopic cholecystectomy: timing of repair and long-term outcomes. Arch Surg. 2010;145(8):757-63.
- 15. Strasberg SM, Helton WS. An analytical review of vasculobiliary injury in laparoscopic and open cholecystectomy. HPB. 2011;13(1):1-14.
- 16. Huang Q, Liu C, Zhu C, Xie F, Hu S. Postoperative anastomotic bile duct stricture is affected by the experience of surgeons and the choice of surgical procedures but not the timing of repair after obstructive bile duct injury. Int J Clin Exp Pathol. 2014;7(10):6635-43.
- 17. Tantia O, Jain M, Khanna S, Sen B. Iatrogenic biliary injury: 13,305 cholecystectomies experienced by a single surgical team over more than 13 years. Surg Endosc. 2008;22(4):1077-86.
- 18. Waage A, Nilsson M. Iatrogenic bile duct injury: a population-based study of 152 776 cholecystectomies in the Swedish Inpatient Registry. Arch Surg. 2006;141(12):1207-13.
- 19. Connor S, Garden J. Bile duct injury in the era of laparoscopic cholecystectomy. Br J Surg. 2006;93(2):158-68.
- 20. Windsor JA, Pong J. Laparoscopic biliary injury: more than a learning curve problem. Aust N Z J Surg. 1998;68(3):186-9.
- 21. Shaffer EA. Epidemiology of gallbladder stone disease. Best Pract Res Clin Gastroenterol. 2006;20(4):981-6.
- 22. Way LW Dunphy JE. Biliary stricture. Am J Surg. 1972;124:287-95.

- 23. Genest JF, Nanos E, Grundfest-Broniatowski S, Vogt D, Hermann RE. Benign biliary stricture: an analytical review (1970 to 1984). Surgery. 1986;99(4):409-13.
- 24. Giger UF, Michel JM, Opitz I, Th Inderbitzin D, Kocher T, Krähenbühl L; Swiss Association of Laparoscopic and ThoracoscopicSurgery (SALTS) Study Group. Risk factors for perioperative complications in patients undergoing laparoscopic cholecystectomy: analysis of 22,953 consecutive cases from the Swiss Association of Laparoscopic and Thoracoscopic Surgery database. J Am Coll Surg.2006;203(5):723-8.
- 25. Wu YV, Linehan DC. Bile duct injuries in the era of laparoscopic cholecystectomies. Surg Clin North Am. 2010;90(4):787-802.
- 26. Karvonen J, Gullichsen R, Laine S, Salminen P, Gronroos JM. Bile duct injuries during laparoscopic cholecystectomy: primary and long-term results from a single institution. Surg Endosc. 2007;21(7):1069-73.
- 27. Jarnagin WR, Blumgart LH. Operative repair of bile duct injuries involving the hepatic duct confluence. Arch surg. 1999;134(7):769-75.
- 28. Abdelhamid MS, Sadat AM, Abouleid AH, Mohamed AMA, Negida MA, Gharib AZ, et al. Repair options following iatrogenic bile duct injuries. Journal of Surgery. 2015;3(5):50-5.
- 29. Nordin A, Grönroos JM, Mäkisalo H. Treatment of biliary complications after laparoscopic Cholecystectomy. Scand J Surg. 2011;100(1):42-8.
- 30. Khalaf AM. Management of bile duct injuries: comparative study between Roux-en-Y

- hepaticojejunostomy and primary repair with stent placement. J Arab Soc Med Res. 2013;8(2):89-95.
- 31. Sarmiento JM. Hepaticojejunostomy: Indications and surgical technique. Operative Techniques in General Surgery. 2000;2(4):295-303.
- 32. Pandya JS, Waghmare SB, Thakre MM, Doctor NH. Challenges in management of right aberrant hepatic duct injury. Int J Hepatobiliary Pancreat Dis. 2016;6:6-9.
- 33. Coakley FV, Schwartz LH, Blumgart LH, Fong Y, Jarnagin WR, Panicek DM. Complex postcholecystectomy biliary disorders: preliminary experience with evaluation by means of breath-hold MR cholangiography. Radiol. 1998;209(1):141-6.
- 34. Jabłońska B, Lampe P. Iatrogenic bile duct injuries: etiology, diagnosis and management. World J Gastroenterol. 2009;15(33):4097-104.
- 35. Silva MA, Coldham C, Mayer AD, Bramhall SR, Buckels JA, Mirza DF. Specialist outreach service for on-table repair of iatrogenic bile duct injuries a new kind of "traveling surgeon". Ann R Coll Surg Engl. 2008;90(2):243-6.
- 36. Granados-Romero JJ, Estrada-Mata AG, Espejel-Deloiza M, Ceballos-Villalva JC, Contreras-Flores EH, León-Mancilla B, et al. Current perspective in the treatment of bile duct injuries. Int J Res Med Sci. 2016;4(3):677-84.

**Cite this article as:** Ali AMA, Abdelhameed HF. Post-cholecystectomy bile duct injuries: When to repair?. Int Surg J 2018;5:1649-56.