

# Biliary tract injuries after lap cholecystectomy—types, surgical intervention and timing

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*Contributions:* (I) Conception and design: All authors; (II) Administrative support: All authors; (III) Provision of study materials or patients: All authors; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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**Abstract:** Bile duct lesions, including leaks and strictures, are immanent complications of open or laparoscopic cholecystectomy (LC). Endoscopic procedures have gained increasing potential as the treatment of choice in the management of postoperative bile duct injuries. Bile duct injury (BDI) is a severe and potentially life-threatening complication of LC. Several series have described a 0.5% to 0.6% incidence of BDI during LC. Early recognition and an adequate multidisciplinary approach are the cornerstones for the optimal final outcome. Suboptimal management of injuries often leads to more extensive damage to the biliary tree and its vasculature. Early referral to a tertiary care center with experienced hepatobiliary surgeons and skilled interventional radiologists would appear to be necessary to assure optimal results.

**Keywords:** Biliary tract; laparoscopic cholecystectomy (LC); hepatobiliary surgeons

Submitted Mar 19, 2016. Accepted for publication Mar 24, 2016.

doi: 10.21037/atm.2016.05.07

View this article at: <http://dx.doi.org/10.21037/atm.2016.05.07>

## Introduction

Bile duct strictures and biliary leakages are severe complications after cholecystectomy procedure. Biliary leakages are considered an early complication and biliary strictures are a late complication. It is observed that the rate of clinically-relevant bile leaks after conventional open cholecystectomy ranges was between 0.1% and 0.5% (1-3). Biliary leakages have increased after the development of laparoscopic cholecystectomy (LC) by up to 3% (4-7). Therefore the surgical management of bile duct lesions is afterward required to resolve this issue. However, surgical management has been associated with high mortality and morbidity (8,9). Endoscopic procedures are nowadays mostly used in the management of postoperative bile duct injuries. There are several endoscopic techniques such as biliary stent placement, biliary sphincterotomy, and nasobiliary drainage (10-12). It has been observed that

endoscopic therapy can reduce the transpapillary pressure gradient. Moreover, during endoscopic procedures the transpapillary flow is improved and as an additional effect, the extravasation out of the biliary tract is reduced. It has been observed that the healing of bile duct lesions is quicker facilitated during the insertion of a transpapillary endoprosthesis or a nasobiliary drainage. We do not have a long-term follow-up for the endoscopic treatment of bile duct injury (BDI), including leakages and strictures, however; endoscopic procedures are considered to be safe and efficient. It is known that gallstone disease is a common digestive health problem (13). LC is now the golden standard for gallbladder removal in the management of symptomatic cholelithiasis; it has a decreased postoperative mortality and morbidity. However, it has been observed that bile duct injuries are more severe and common when compared to open cholecystectomy (14-17). There is a

**Table 1** Corlette-Bismuth classification

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Type 1 Low common hepatic duct (CHD) stricture, with a length of the CHD stump of >2 cm
Type 2 Middle stricture: length of CHD <2 cm
Type 3 Hilar stricture, no remaining CHD, but the confluence is preserved
Type 4 Hilar stricture, with involvement of confluence and loss of communication between right and left hepatic duct
Type 5 Combined common hepatic and aberrant right hepatic duct (RHD) injury, separating from the distal common bile duct (CBD)

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**Table 2** Strasberg classification

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Type A Bile leak from cystic duct or liver bed without further injury
Type B Partial occlusion of the biliary tree, most frequently of an aberrant right hepatic duct (RHD)
Type C Bile leak from duct (aberrant RHD) that is not communicating with the common bile duct (CBD)
Type D Lateral injury of biliary system, without loss of continuity
Type E Circumferential injury of biliary tree with loss of continuity

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report where the incidence of biliary tract injuries was found to be up to 0.6% for laparoscopic versus 0.1% for open cholecystectomy (17). These injuries lead to high morbidity, mortality, and prolonged hospitalization (18). If major bile duct injury (MBDI) occurs, then it requires a skilled and experienced hepatobiliary surgeon at a tertiary referral center (19). Collaboration with surgeons, interventional radiologists and gastroenterologists is usually necessary for the care of such injuries. We are going to present the classifications of bile duct injuries the application of surgical treatment (when needed) and the timing of the application of surgical treatment.

### Classification of bile duct injuries

Currently, the classification is based on peripheral leakages, central leakages, and biliary strictures. Siewert *et al.* (20) described type 1 lesions which are peripheral leakages and include immediate biliary fistulas. On the other hand, central leakages consist of tangential lesions without structural loss of the bile duct and correspond with type 3 lesions (20). Type 2 is lesions occur when biliary strictures

comprehend late strictures without obvious intraoperative trauma (20). *Tables 1* and *2* present the Corlette-Bismuth classification and Strasberg classification under radiographic guidance using contrast fluid, biliary leakages and bile duct strictures.

### Bismuth classification

H. Bismuth in 1982 is the first to create a classification. Since then many groups have provided additional classifications (see below). The Bismuth classification is based on the location of the injury in the biliary tract. This classification includes five types of bile duct injuries according to the distance from the hilar structure especially bile duct bifurcation, the involvement of bile duct bifurcation, the level of injury, and individual right sectoral duct (21). Type I involves the common bile duct (CBD) and low common hepatic duct (CHD) >2 cm from the hepatic duct confluence.

Type II includes the proximal CHD <2 cm from the junction. Type III is hilar injury with no residual CHD confluence intact. Type IV occurs when the right and left hepatic ducts become separate. Type V involves the aberrant right sectoral hepatic duct alone or with a concomitant injury of CHD. The major disadvantage of the Bismuth classification is that it does not include a broad range of biliary injuries.

### Strasberg classification

Whereas the Strasberg classification is a modification of the Bismuth classification provides a differentiation between small and serious injuries during LC as type A to D. Type E of the Strasberg classification is considered an analog of the Bismuth classification (22). The Strasberg classification is very easily applied to bile duct injuries. The Strasberg classification does not describe additional vascular involvement and for this reason, it cannot demonstrate a significant discrimination for specific injury patterns (*Table 2*).

### McMahon classification

McMahon *et al.* classified the injury by the width of BDI. In specific lacerations under 25% of the CBD diameter or cystic-CBD junction were classified as a minor injury. The transection or laceration of over 25% of CBD diameter and postoperative bile duct stricture are classified as major injury (23).

### *Stewart-Way classification*

According to Stewart-Way classification, there are four types (24). Class I injury occurs when CBD is mistaken for the cystic duct, and the error is recognized before CBD is divided. Class II injuries are done by damage to CHD from clips or cautery. These kinds of damages occur in cases where visibility is limited due to bleeding or inflammation. Class III injury, which is the most common type, occurs when CBD is mistaken for the cystic duct. There three cases the first where the common duct is transected, the second which includes the junction of the cystic and the third where the common duct is excised or removed. Class IV injuries involve damage to the right hepatic duct (RHD), there are two main causes the first this structure is mistaken for the cystic duct, and the second because it is injured during dissection. In the Stewart-Way classification both complex bile duct and vascular injuries are included.

### *Hannover classification*

The author Bektas *et al.* proposed a new classification system named which was named Hannover classification system. This classification system was introduced after observation of 72 iatrogenic bile injuries after LC. The Hannover classification system classifies bile duct injuries into five types from A to E (25). Type A is considered as peripheral bile leakage. Type B is found when stricture of CHD or CBD is observed without injury. Type C is considered when lateral CHD or CBD injury is found. Type D occurs when a total transaction of CHD is observed. Type E is considered when bile duct stricture of the main bile duct occurs without bile leakage at postoperative state. Moreover, vascular injuries are included in type C and type D classification. The Hannover classification was able to distinguish a total of 21 injury patterns in a small group of patients. The advantage of using the Hannover classification is that it makes an association between the discrimination of classifiable injury patterns and the appropriate surgical treatment. This Hannover classification provides discriminators for the localization of tangentially or entirely transected bile ducts in correlation with the bifurcation of the hepatic duct, which is the primary disadvantage of other classification systems.

### *Mattox classification*

Another classification system has also been created,

called the Mattox classification of BDI which takes into consideration the types of injuring factors (laceration, contusion, transection, perforation, diversion or interruption of the bile duct) (26). There are also other several classifications for induced BDI during LC (27-30).

### **Surgical management**

When biliary tract injuries occur, surgical treatment has to be applied. The time of diagnosis after the initial injury and classification (which includes the extent and level of the injury) is critical for optimal treatment. There are several injuries which can create short- and long-term complications (intra-abdominal fluid collections and biliary fistula or abscess, biliary or anastomotic strictures, biliary cirrhosis and cholangitis) (31,32).

### *Recognized at LC*

Several studies have presented data that a minority of bile duct injuries (8% to 33%) referred to tertiary care centers have been recognized at the time of LC (32-36). Usually, unexplained bile drainage raises the suspicion of a biliary injury. In the case where a biliary injury is suspected, the surgeon must have the biliary anatomy cholangiographically, to avoid any additional dissection. This is imperative, otherwise further injury or devascularize the bile duct might occur (31). In several cases, it is necessary to perform an open procedure and identify biliary anatomy. In some cases, an injury is suspected after completion of the cholecystectomy from ongoing biliary drainage. In the case where an injury is confirmed by laparoscopic cholangiography and complex biliary reconstruction cannot be performed, several drains may be placed laparoscopically, and the patient transferred to a specialized hepatobiliary unit (31). There is the choice also a small red rubber catheter placement into an injured or transected bile duct which enables opacification of the biliary tract postoperatively. This method will assist in future attempts at the placement of a percutaneous transhepatic catheter. Moreover, a closed suction drain should be left in the subhepatic space. The best option for the patient would be that an experienced surgeon performing the LC will make an immediate repair and minimize the morbidity associated with the injury (32,37). Based on the operative findings the appropriate operative repair will take place. In the case where the transected duct is 4 mm or larger, then multiple drains will be placed in hepatic segments

or the entire right or left lobe and should be repaired or re-implanted. In the case of ducts <3 mm then it can be safely ligated if cholangiography demonstrates filling of a single hepatic segment (31). T-tubes can be used in the case of partial transections of the bile duct from a separate choledochotomy. Furthermore, complete ductal transections include loss of some ductal length because of clip application or excision of a segment of the bile duct. It is known that the debridement of the transected end back to normal tissue will lead to loss of additional ductal length. Additionally, end-to-end ductal repairs are rarely achieved without some tension even with a further mobilization of the duodenum, however; a restructured rate approaching 100% has been reported (24). It has been reported that a tension-free biliary-enteric anastomosis to a Roux-en-Y jejunal limb achieves the best long-term results, and it is preferred in most cases (24,32). It is imperative that a Roux-en-Y limb is used compared to a choledochoduodenostomy because the latter may cause an anastomotic leak which will result in a duodenal fistula (31).

#### *Injuries recognized in the postoperative period*

In the majority of the patients, with a BDI will present within the first few weeks following LC (31,32). The main symptoms will be fever, pain, and mild hyperbilirubinemia (2.5 mg/dL) from a biloma or bile peritonitis. Usually, bile will be observed leaking externally from a drain or surgical incision. In the case of injuries involving occlusion of the common hepatic or bile duct without an intraperitoneal bile leak, the main symptoms will be jaundice with or without abdominal pain. In some cases, patients will present cholangitis or cirrhosis from a remote BDI at a later time probably months or years after biliary surgery (22). In severe early postoperative cases, patients will present with sepsis from cholangitis or intra-abdominal fluid collections. In the case of a suspected bile leak, ultrasound or and an abdominal computed tomography (CT) scan or will identify peritoneal fluid, biloma, or an abscess. In the case of perihepatic fluid collections, drainage can be applied percutaneously. Usually, broad-spectrum parenteral antibiotics covering the common biliary pathogens are initiated (31). When a percutaneous drainage is applied, and ongoing biliary drainage is observed then of active bile leak is verified. There is also the case where the diagnosis is confirmed noninvasively with a technetium iminodiacetic acid (Tc-IDA) scan. A sinogram can also be used after a fibrous tract has formed.

In the case where there is no external bile leak, the biliary anatomy is defined with an endoscopic retrograde cholangiopancreatography (ERCP) (22). In the case of cystic duct bile leaks which are detected during ERC, the best management would be the placement of a biliary endoprosthesis and percutaneous drainage of any intra-abdominal fluid collection (22). The diagnostic evaluation is slightly different in a patient with jaundice and suspected BDI. There are two examinations usually performed, firstly a CT scan (abdomen) and secondly an ultrasound which will evaluate and demonstrate the presence of intrahepatic and extrahepatic ductal dilation. These two examinations will also provide some anatomic information regarding the level of the injury, if one segment or lobe is affected or whether the entire intrahepatic ductal system is involved. When an intrahepatic ductal dilation occurs from a biliary stricture, then percutaneous transhepatic cholangiography and placement of a transhepatic stent are necessary to decompress the biliary tree and relieve jaundice also by doing this the proximal extent of the injury will be defined. And appropriate treatment will be applied. It is necessary that the biliary anatomy is defined including all ductal segments as this information is the most important factor in the success of any operative repair (24). The so-called “isolated segments VI and VII” are suspected if these ducts aren’t visualized on cholangiography, and then a CT scan or magnetic resonance cholangiography should be performed (19,38). It has been observed that in the majority of the repairs performed without preoperative cholangiography (96%) or with incomplete cholangiography (69%) then success is reduced significantly (24). If complete cholangiography is performed then, surgical reconstruction has a success rate of up to 84% (24). If sepsis and biliary leak are controlled then there is no reason to rush to surgical repair of the bile duct stricture. Moreover, postoperative injuries are best managed with operative exploration and repair in 6 to 8 weeks after acute inflammation has resolved from the perihepatic bile leak (31,39). It is of the most importance that attention is given to fluids, acid-base balance and electrolytes during this interim period. The goal of surgical repair is a tension-free, mucosa-to-mucosa duct enteric anastomosis, which in the majority of the cases an end-to-side Roux-en-Y choledochojejunostomy or, more commonly, a Roux-en-Y hepaticojejunostomy is performed. There is the case where there are strictures involving the bifurcation or left or RHDs, and, therefore, bilateral hepaticojejunostomies may be necessary.

Transhepatic stents are useful technical aids which placed preoperatively to identify the hepatic ducts particularly (32,40). The technique requires that the bile duct is divided at the distal extent of the stricture, and afterwards the distal end is oversewn. The ductal segment containing the stricture is resected, and finally, an end-to-side hepaticojejunostomy is constructed over a silastic transhepatic stent. Afterwards, the transhepatic stents are finally left in postoperatively for several months.

## Results

It has been reported that patients with bile duct stricture or injury when operative repair was performed they have had excellent results at tertiary expert referral centers (32-36). In several series of operative repair the mortality observed was very low (0% to 3%). It has been observed that patients who had been scheduled for an elective procedure and short-term hospitalization had a high morbidity rate with complications such as; subhepatic or subphrenic abscess, cholangitis, bile leak, and hemobilia) both pre- and post-operatively. It has been observed that long-term follow-up is necessary to evaluate fully the results of biliary reconstruction for BDIs (41). Moreover, restenosis of a biliary-enteric anastomosis can occur many years following operative repair. Up to two-thirds of recurrences have been observed to become symptomatic within 2 years after repair. There have been cases of restenosis after 10 years after surgery (41). Lillemoe *et al.* (32) reviewed the long-term results of 89 patients with laparoscopic bile duct injuries managed at “The Johns Hopkins Hospital” and observed that 82 patients were referred from an outside institution and that the two-thirds of these patients had undergone at least one laparotomy and one attempted repair. It was observed that the majority (81%) of these patients was women, and their mean age was 41 years. The average time of interval from LC to referral was 7.7 months. The most frequent symptoms of presentation were obstructive jaundice (37%), ongoing biliary leak or fistula (38%), or cholangitis (22%) (32). In all cases, percutaneous cholangiography and biliary drainage were applied to control the bile leak and associated sepsis. Moreover, patients with a perihepatic fluid collection or a biloma also underwent percutaneous drainage for management. Additionally, the treatment of these patients included percutaneous balloon dilation and long-term stenting (n\_28, all repaired previously elsewhere) or for most of them surgical

biliary reconstruction (n\_59). In this study, 25% of the patients had been managed operatively and they have had one prior attempt at operative repair, and only 8% of these injuries were initially recognized upon LC. The classification of these patients (61%) was Bismuth level 3, 4, or 5. In these patients, biliary reconstruction included of a Roux-en-Y hepaticojejunostomy over one or more transhepatic silastic stents. In this study, two-thirds of the patients were stented postoperatively for at least 9 months. There was a classification by the authors according to the result as follows: excellent (no symptoms), good (mild symptoms were not requiring treatment), or poor result (additional treatment). Moreover, the positive outcome was considered according to the first two groups 92% in total (excellent 79%, good 13%) with a mean follow-up of 33 months. It was observed that there were four treatment failures after surgical reconstruction which became symptomatic within 27 months of reconstruction (32). The main factors which influenced the outcome were again the type of stricture and the level of the stricture or injury. It was observed that proximal strictures had a lower success rate when compared with distal strictures. In general, when patients had an initial repair of their ductal injury a lower restenosis rate was observed than patients undergoing operative revision. According to the authors, the length of postoperative stenting had nothing to do with the outcome (32). Other authors such as Stewart-Way reported again as the previous authors that early treatment of BDI during LC results in favorable outcomes (88 patients) (24). Sixty-four of these patients were operated by a primary surgeon while 46 patients repaired at a tertiary referral center. In this study, several factors determined the success of the repair. Firstly, treatment failure was associated with incomplete preoperative cholangiography, secondly, Roux-en-Y hepaticojejunostomy was successful more than repairs for ductal transections. Moreover, attempts at repair by the primary surgeon were more likely to fail at the hospital primary care than repairs performed at tertiary referral centers. Again high success rates have been reported from centers when median follow-up was conducted (24). Complications are also associated with medical and financial costs. Savader *et al.* reviewed in his study the hospital course and charges related to the treatment of 49 patients with bile duct injuries. These patients underwent surgical repair at “The Johns Hopkins Hospital” (37). It was observed in this study that the early BDI recognition immediately at the time of LC had fewer days of hospitalization and less financial costs (37).

## Discussion

The most common BIs include biliary leakage, biliary fistula, and hemobiliary. There have been several proposals recently to classify postoperative strictures and bile duct injuries. The Corlette-Bismuth classification made a proposal which is based on the length of the proximal biliary stump, however; not on the nature and length of the lesion. McMahon has proposed a detailed subdivision into minor and major bile duct injuries. Minor injuries are considered when laceration of the cystic to CBD junction and laceration of the CHD is <25% of the duct diameter. Major injuries are considered when laceration is >25% of the bile duct diameter, also, if transection either of the common hepatic or CBD occurs or if there is a development of postoperative stricture. There is also the Strasberg classification which is considered the most detailed classification as it includes all types of injuries (15). Unfortunately, it is almost impossible to obtain the exact incidence rate of iatrogenic bile duct injuries because bile duct injuries could be attributed to the negligence of surgeons or anatomical abnormalities or even agenesis of the gallbladder (42). When a MBDI after LC occurs it is difficult to treat the problem and depends on the time of diagnosis after the initial injury and the type, extent and level of the injury. Immediate management is necessary to avoid fistulas, sepsis, and obstruction of the biliary system. MBDI identification and categorization of the type is necessary in order to identify the next steps. After classification, repair of the injury should be performed. There should be a postoperative follow-up, and a prolonged treatment protocol is necessary. Furthermore it has been reported that the incidence of MBDI after LC is higher than that after open cholecystectomy (43). There are risk factors such as; dangerous anatomy, dangerous pathology, and dangerous surgery (44). There is a great chance that MBDI is missed during LC (32). There are anatomical structure variations of Calot's triangle which are not very clear because of congestion, edema, and fragility of the tissues surrounding the cystic duct in acute suppurative or gangrenous cholecystitis. Therefore, the exposure of peritoneal attachments in Calot's triangle is necessary in order to identify anatomical variations, and the cystic duct should not be separated at the junction of the common hepatic, and cystic ducts are positively identified. In some cases, fibrous tissue scars are identified in Calot's triangle in atrophic cholecystitis. Nowadays injuries to the bile duct system during LC are not associated only with the experience of the surgeon and is also not related to the

“learning curve” of the operating surgeon as suggested in the past (45). Recent studies demonstrated that the in one-third of all bile duct injuries, the basic cause use of a nonproper approach to the fundamental structures of the extrahepatic biliary tree. In specific because of a visual perceptual illusion (45). Another issue is inflammation or chronic fibrosis at the time of the initial procedure which does not allow the proper evaluation of the situation. Currently, the role or use of Intraoperative laparoscopic ultrasonography and cholangiography in prevention of MBDI during LC is a matter of ongoing debate (46). Upon referral, all patients with suspected BDI should undergo Ultrasound and CT of the abdomen so that any dilatation of the bile duct system or fluid collection can be observed. In most cases those techniques must be combined with magnetic resonance cholangiopancreatographies (MRCP), ERCP or even percutaneous transhepatic catheterizations (PTC) in order to identify the biliary anatomy (15). In cases where patients do not recover after cholecystectomy then these patients are considered candidates for having a BDI. In the case of BDI the patient should be transferred to a tertiary care center with expertise in biliary surgery, by doing this we limit further operations, complications, time to definitive repair, and finally mortality. Moreover, pre-operative imaging studies such as MRCP, ERCP, and PTC also correctly identify all necessary information regarding MBDI (15,47). Surgery treatment should be performed only when the patient is stabilized and the MBDI has been properly classified because the success of the operating procedure depends on the proper and accurate identification of the MBDI. In the case of the early postoperative period (2 to 7 days), which involves a relatively distal lesion below the bifurcation and there is no biliary leakage, sepsis or abscess formation then early reconstruction can be considered. In the case of bifurcation, then percutaneous biliary drainage is preferred with an elective repair after 6 to 8 weeks (15). The control of sepsis with antibiotics and proper fluid balance should be considered the primary goals of the initial management of BDI. If the patient is stable and the appropriate care is provided then proceeding with surgical reconstruction is not considered urgent.

Moreover, when sepsis and leaks are controlled, and the MBDI is classified, and then a hepaticojejunostomy should be modified to a Roux-en-Y jejunal limb, or less commonly an end to side Roux-en-Y choledochojejunostomy. Also, in some cases, the technique of Roux-en-Y hepaticojejunostomy has been proposed. In the cases of strictures involving the bifurcation of left or RHDs, bilateral hepaticojejunostomies

may be necessary. Association of the level of injury and the outcome of the surgical procedure has been proposed. There are also other factors that foresee the surgical outcome such as; the performance of preoperative cholangiography, include the timing of the repair, the expertise of the surgeon performing the repair, the choice of surgical procedure, and the presence of concomitant vascular injury (32). It has been reported in the literature that the outcome of surgical reconstruction for major lesions or failure of endoscopic treatment depends on the timing of the reconstruction (15). It is proposed that postoperatively the transhepatic catheters should stay for external gravity drainage until day 5, and a cholangiogram should be performed. It is also proposed that upon follow-up cholangiograms should be obtained at 1 month and 3 months postoperatively, if necessary, more often or earlier. Moreover, catheters should be removed between 3 and 6 months postoperatively, this depends on the level of the injury, as well as the appearance of the cholangiogram (43). Recurrent biliary stricture has been observed in 10–30% of cases, after open cholecystectomy (48). It has been also noted that patients with recurrent stricture develop more frequently restenosis. Additionally, previous surgical attempts also greatly influence the outcome, because repeated attempts make the stricture even greater, leading to an even more challenging next repair and the result not always favorable.

## Conclusions

MBDI after LC requires a multidisciplinary approach with specialized physicians at tertiary hospitals. Imaging techniques and proper classification is required in order to prevent or treat sepsis, biliary leaks, and collections. Roux-en-Y hepaticojejunostomy should be considered in these cases, since it presents excellent results. In some cases, life-threatening complications can occur if the referral to an expert center is delayed or, rarely, after surgical repair. It has been observed that complications are frequent, however; almost all can be managed non-operatively.

## Acknowledgements

None.

## Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

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**Cite this article as:** Karanikas M, Bozali F, Vamvakerou V, Markou M, Memet Chasan ZT, Efraimidou E, Papavramidis TS. Biliary tract injuries after lap cholecystectomy—types, surgical intervention and timing. *Ann Transl Med* 2016;4(9):163. doi: 10.21037/atm.2016.05.07