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Brief Overview about Iatrogenic bile duct injury Management

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Abstract: Background: As a major concern in gastrointestinal surgery, iatrogenic bile duct injuries (BDIs) during laparoscopic cholecystectomy continue to have a major influence on patients' standard of living. Classification of BDIs, suggested methods for biliary lesion prevention, risk factors, and management challenges based on injury recognition time, injury extent, patient clinical status, and access to experienced hepatobiliary surgeons were the main goals of this review. In order to achieve the best possible result after surgery, it is critical to identify BDI as soon as possible and to reduce the time between diagnoses. The therapeutic care of biliary lesions might involve endoscopic, radiologic, or surgical procedures, depending on their kind and severity.

Keywords: *Iatrogenic bile duct injury*

Introduction

The "Bismuth classification"5 used to categorize biliary injuries according to their severity; before to the development of LC, bile duct stricture was the most common lesion to the biliary tract. Based on factors such as injury severity, distance from the hepatic hilus, involvement of the bile duct bifurcation, and specific right sectoral duct, five distinct types of bile duct lesions are recognized. After some time had passed, Strasberg et al.6 suggested an alternative categorization that was comparable to Bismuth's but included other biliary injuries, including biliary leaks, that were more prevalent during the laparoscopic period. As seen in Table 1, the "Strasberg classification" categorized biliary injuries into types A through E. According to an alternative system put out by McMahon et al.7, biliary injuries can be categorized as either major or minor. Major injuries include transection or laceration that exceeds 25% of the common bile duct (CBD) diameter or postoperative bile duct stricture, while minor injuries include lacerations that do not exceed 25% of the CBD diameter or the cystic duct-common hepatic duct (CD-CHD) junction. Figure 1 shows the four categories that made up the "Stewart-Way classification"8 according to the cause and structure of biliary damage. The examination of

operative reports led to this categorization, which explains the cognitive processes and human errors that contribute to BDI mechanisms. There are two instances of class I injury: 1) In 72% of cases, the CBD is mistaken for the cystic duct; however, the error is detected before the CBD is divided. Alternatively, in 28% of cases, the cholangiogram catheter is inadvertently extended into the CBD during an incision made in the cystic duct. When the coronary heart is damaged laterally and develops a stricture or leak, this is a Class II injury. When electrocautery or clips are used too near to the CBD, especially in situations where there is restricted vision owing to acute inflammation or significant bleeding, this sort of injury might result. In Class III injuries, which account for almost 60% of all cases, the major bile duct is completely severed, which invariably involves the CD-CHD junction. Injury to the right hepatic artery and transection or leakage of the right hepatic duct (RHD) or posterolateral sectoral duct are examples of class IV injuries.

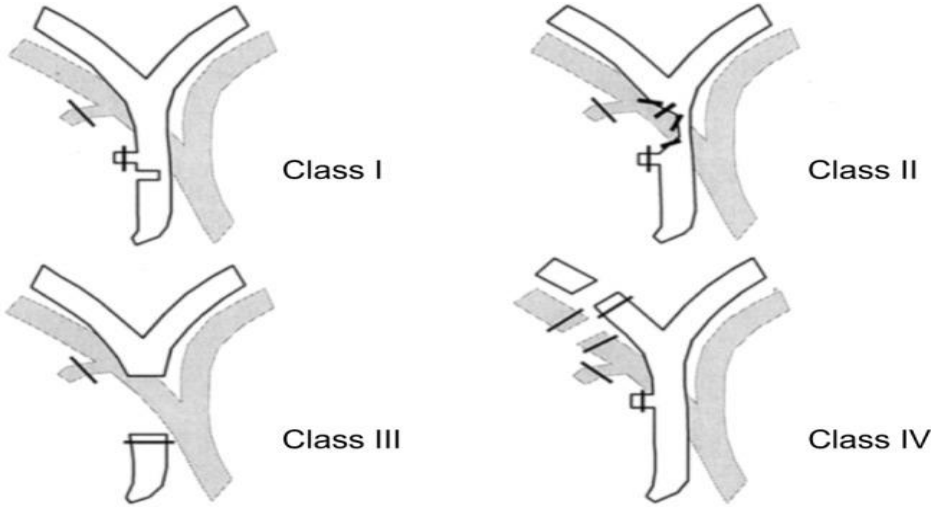

Figure 1
Stewart-Way classification of bile duct injuries.

Table 1

Bismuth and Strasberg classification

Bile duct injury	Bismuth	Strasberg
Cystic duct leak or leaks from small ducts in liver bed	–	A
Occlusion of an aberrant RHD	–	B
Leak from an aberrant RHD	–	C
Lateral injury to CBD (<50% circumference)	–	D
CHD stricture, stump >2 cm	Type I	E1
CHD stricture, stump <2 cm	Type II	E2
Hilar stricture with preserved biliary confluence	Type III	E3
Hilar stricture with involvement of confluence	Type IV	E4
Stricture to an aberrant RHD and to CHD	Type V	E5

Prevention of iatrogenic BDI

Over the years, various methods have been proposed and described in the scientific literature to prevent iatrogenic biliary tract lesions. They are summarized in Table 2. The “critical view of safety (CVS)” technique was introduced by Strasberg in 199510 and it is considered the gold standard to perform a safe cholecystectomy with identification of biliary structures during dissection. Three criteria are required to achieve the CVS: 1) the hepatocystic triangle must be cleared of adipose and fibrotic tissues; the CBD and CHD must not be exposed; 2) the lower third of the gallbladder must be separated from the liver bed to expose the

cystic plate; and 3) two and only two structures should be seen entering the gallbladder. CVS was conceived not as a way to do LC but as a way to avoid biliary injury.

Table 2

Summary of proposed methods to prevent bile duct injuries

- Critical view of safety (CVS) method
- Infundibular technique
- Antegrade dissection
- Subtotal cholecystectomy
- Anatomic landmarks:
  - Rouviere's sulcus
  - Calot's node
  - B-SAFE method
- Intra-operative cholangiography (IOC)
- Laparoscopic ultrasound (LUS)
- Near-infrared fluorescent cholangiography (NIRF-C)
- Conversion to open surgery

In such cases, some surgeons prefer performing the *infundibular method* in order to work very close to gallbladder infundibulum, reducing the risk of biliary injuries, but care should be taken with "hidden cystic duct" syndrome which presents a deceptive appearance of a false infundibulum that misleads the surgeon into identifying the CBD as the cystic duct.11 The "antegrade dissection or fundus first/dome-down technique" represents a way of dissection from the gallbladder fundus up to the infundibulum away from Calot's triangle.12 In this way, the gallbladder is left pedunculated by the cystic artery and cystic duct, which can be clipped and divided in turn, reducing the risk of biliary lesions. Another easy, safe, and definitive operation for the "difficult gallbladder" is described and has been termed "subtotal or partial cholecystectomy",13 consisting in leaving the posterior wall of the gallbladder attached to the liver and securing the cystic duct at its origin from within the gallbladder.

Different anatomic landmarks have been described: among them, in 1924, Henri Rouvière, a French surgeon, described a 2–5 cm sulcus running to the right of liver hilum, anterior to the caudate lobe, and usually containing the right portal triad or its branches.14 It can be considered a useful landmark site to start dissection of the hepatocystic triangle during LC.15 The "Rouvière's sulcus" is present in the majority of patients, ranging from 68% to 90%,16 and is clearly visible during laparoscopy, being visible in one form or the other (a sulcus, a slit, or a scar). Another anatomic landmark to guide gallbladder dissection is represented by the "cystic lymph node" or Mascagni's node, which always lies lateral to the biliary tree and should form the medial end point of dissection.17

Some authors proposed a mnemonic "B-SAFE method", by using five anatomic landmarks (B, bile duct; S, sulcus of Rouvière; A, hepatic artery; F, umbilical fissure; E, enteric/duodenum) to correctly place their cognitive map during dissection.18

The routine use of "intra-operative cholangiography (IOC)" has been proposed for the better declaration of biliary anatomy, detection of silent CBD stones, and reduction of incidence of BDIs, but it is burdened by morbidity and mortality and hence should be performed in facilities where the necessary equipment and experience are available.1,19,20 The opinions about the "routine" or "selective" use of IOC still represent a matter of debate.1,19

"Laparoscopic ultrasound (LUS)" was shown to provide highly sensitive mapping of the extra-hepatic biliary anatomy but the difficult learning curve and the lack of randomized controlled trials have reduced its use in clinical practice.21,22

One of the latest innovations in minimally invasive technology is fluorescence image-guided surgery; "near-infrared fluorescent cholangiography (NIRF-C)" represents a novel intra-operative imaging technique that allows a real-time enhanced visualization of the extrahepatic biliary tree by fluorescence.[23–25] NIRF-C well represents a useful method to identify the CVS with the aid of real-time fluorescent vision with a perfect combination between surgical anatomy and technical innovation, as shown in Figure 2.[26]

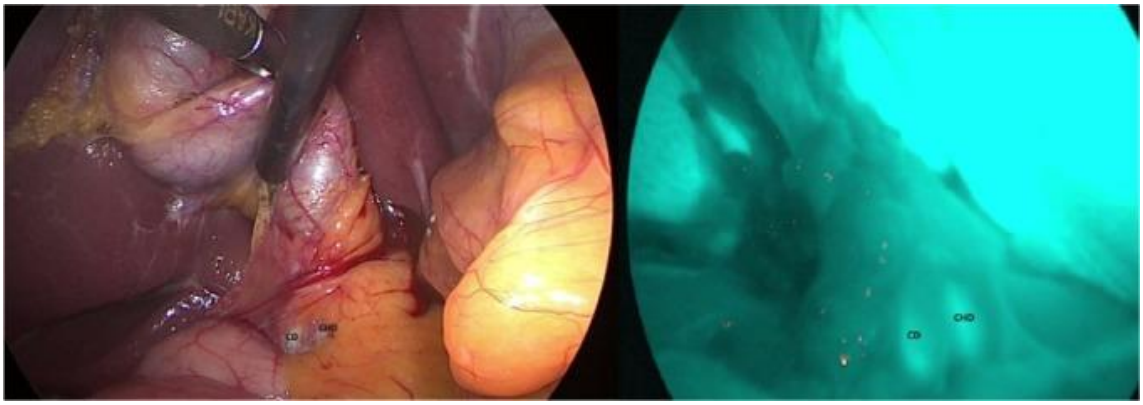

Figure 2
Intra-operative real-time identification of biliary structures with visible light (VL) on left and by fluorescence (NIRF-C) on right.

In some difficult situations, the opinion of a surgical colleague in vicinity during operation may also represent a valid alternative, the so-called "colleaguography", in place of IOC or other methods, as proposed by some authors.[27]

Despite the plethora of publications and debates, there is still no consensus as to which method is the best to prevent BDIs during LC. Recently, highest consensus was achieved on the importance of the CVS and NIRF-C, as well as ante-grade dissection or fundus first/dome-down technique and partial cholecystectomy as alternative techniques.[28,29]

A general recommendation is that in all cases of complicated cholecystectomies, the surgeon must not hesitate when considering conversion to open approach because there is no substitute for experience and caution in biliary surgery.

Risk factors

There are several risk factors which can contribute to the iatrogenic injury of the biliary tract: anatomical factors; patient-related factors; and factors related to the gallbladder disease, the surgical technique, and the surgeon. Among the anatomical factors, the numerous anatomical variants of the biliary tract represent a possible cause of iatrogenic lesion, for example, the different variants of the cystic duct, such as short cystic duct, cystic duct running parallel to the CBD, anomalies of the CD-CHD junction, presence of the hepatocystic duct, accessory cystic duct, the existence of aberrant bile ducts (eg, Luschka duct).[30] Among the patient-related factors, severe obesity, previous surgery on the biliary tract, and underlying liver disease seem to be predisposing factors for peri-operative complications.

However, acute cholecystitis causes a series of modifications of the local anatomy (adhesions, thickening of the tissues, inflammation, bleeding) that are associated with an increased risk of iatrogenic lesion.[31,32] Among the factors related to the technique, the laparoscopic approach itself represents a risk factor, hence the importance of a correct "learning curve" for young surgeons.[33,34] The human factors also play a crucial role in the pathophysiology of the iatrogenic bile lesion: the excessive safety of the surgeon, the rush to finish the intervention, the fatigue and personal concerns of the surgeon, the performance anxiety, the superficiality of the surgical act, and the lack of humility in converting to open surgery in doubtful cases may determine a relevant damage to the biliary tree.[8–35]

LC can be seen as a trivial intervention but it could hide many difficulties with dramatic consequences. For these reasons, caution and experience are essential in biliary surgery.

Clinical presentation

If an iatrogenic lesion is not identified during surgery, its type and magnitude will determine the patient's clinical presentation. In the early stages of what could be a biliary leak, symptoms like anorexia, nausea, vomiting, bloating, overall discomfort, and extensive stomach pain may manifest. Although there may be a lot of bile in the patient's belly, the clinical presentation of biliary peritonitis is quite rare. Because these symptoms are so nonspecific, the progression of biliary leak is also exceedingly modest. The classic Charcot's triad, which includes right hypochondrium pain, fever, and jaundice, will be presented by patients with stricture at level of the CBD, in instances when the CBD is mistaken for the cystic duct. It is generally advised that if the usual postoperative course following LC is suddenly disrupted, it could indicate potential harm to the biliary tract. These considerations highlight the significance of thorough patient clinical evaluations. The result of the operation depends on how quickly the diagnosis is made.

When it is acknowledged

Critically important is the prompt diagnosis of BDI. Optimal results are achieved when BDIs are identified during surgery, which usually means prompting urgent surgical correction. However, only around 25% to 30% of BDIs are identified during surgery, and not all surgeons conduct intra-operative cholangiography.36,37A high-volume hepatobiliary facility should be contacted promptly after inserting an intra-abdominal drain in the event that the surgeon is not experienced. A surgeon with experience in biliary repair appears to be the most effective in managing these types of injuries, according to a number of studies.37–39Recognizing an intra-operative lesion depends on a number of things, the most critical of which is the surgeon's knowledge to look out for BDIs. It is common for a diagnosis to be made within the first six weeks following surgery, although it can happen at any point after that. Accurate diagnosis is aided by a thorough clinical assessment. Indications of biliary peritonitis, abnormal or persistent right hypochondrium abdominal pain, bile drainage leakage (if inserted during surgery), fever, jaundice, and elevated liver function tests can all be used to diagnose an iatrogenic lesion of the biliary tree. The proper diagnosis of the damage, its extent, and severity, as well as the planning of treatment methods, necessitates radiologic studies. The initial diagnostic method for detecting liver collections, CBD dilatation, and related vascular abnormalities is abdominal ultrasonography.40Primary imaging studies that can detect ascites, biliary blockage with upstream dilatation, lobar hepatic atrophy, signs of secondary biliary cirrhosis, or focal intra-or peri-hepatic fluid collections include abdominal computed tomography (CT) scans. Along with the tumor, the CT scan can reveal any nearby vascular abnormalities, such those in the right hepatic artery.

The "gold standard" for a comprehensive morphological evaluation of the biliary tree is magnetic resonance cholangio-pancreatography (MRCP), which provides information about the biliary tract's integrity in great detail.41,42In bile leaks, contrast-enhanced MRCP (with gadoxetic acid and its salt, gadoxetate disodium), a gadolinium-based contrast agent, yields significantly more information than conventional MRCP.42Using a contrast agent during MRCP not only helps identify the kind of BDI but also the location and anatomical site of active bile leakage by allowing direct observation of contrast material extravasation into fluid collections. As shown in Figure 3, the presence of cystic duct leak at MRCP following gadoxetic acid injection is one example. Hepatobiliary scintigraphy, which involves slowly building up the radiotracer inside the peritoneal cavity, can also demonstrate the presence of an active biliary leak; however, this technique is far less trustworthy. The patient's clinical status (peritonitis, sepsis, tissue healing) can be improved by promptly placing an abdominal drain under radiological guidance if fluid accumulation is detected in ultrasound, CT, or MRCP. A two- to three-month break should be observed prior to operating on Stewart-Way Class III or IV injuries if the treatment delay exceeds one week. During this period, the patient must be prepared for surgery by stabilizing them. Percutaneous drainage is the gold standard for effectively managing inflammation, infection, and accumulation of fluid within the abdomen.37

Clinical supervision

For biliary lesions include cystic duct leaks, Stewart-Way Class I injuries, and the majority of Class II injuries, endoscopic retrograde cholangio-pancreatography (ERCP) plays a significant therapeutic role in determining the best course of treatment.

A sphincterotomy can be performed through endoscopy to reduce pressure in the biliary tree and place a naso-biliary tube or plastic stent to limit or exclude the fistula, depending on the location of the cystic duct leak; this conservative approach is effective in managing cystic duct leaks. Endoscopic treatment for cystic duct or peripheral radical leaks can approach 100% success rate after proper patient selection. According to Rainio et al., endoscopic sphincterotomy is a single treatment that is both effective and cost-efficient. Its success rate is comparable to that of endoscopic sphincterotomy and biliary stenting.44To avoid a second endoscopy, there are now self-expanding biodegradable biliary stents that work well.45Endoscopic treatment has significant limitations when it comes to seeing some types of bile ducts, such as those that are sectioned or otherwise abnormal and do not interact with the CBD (such as an aberrant RHD). Other issues include situations where the bile duct has been completely transectioned, and the difficulty in seeing potential intra-hepatic proximal leaks. The lesion can be better defined and the biliary drainage can be better accomplished with percutaneous transhepatic cholangiography (PTC) in this particular case.

The use of fine monofilament absorbable suture allows for the prompt healing of Stewart-Way Class I lesions, which are identified intraoperatively. Insertion of a T-tube catheter is rather contraindicated, as expansion of the laceration to permit T-tube insertion results in worsening and progression of the injury and an increased chance of stricture.37,46 Stewart-Way Class II injuries consist of lateral injury to the CHD with subsequent stricture and/or leak. The management of biliary leak involves a multidisciplinary approach with endoscopy and radiological-guided drainage as the first therapeutic choices. Stewart-Way Class II injuries with stricture can be treated with several plastic stents and self-expanding coated metallic or biodegradable stents, depending on the seriousness of biliary lesion.45

Stewart-Way Class III and IV therapy is generally operational, but even in such settings Stewart-Way Class III lesions can also be repaired mini-invasively by endoscopic and radiologic extra-anatomical rendezvous reconstruction.47,48 Fiocca et al48 proposed a combined endoscopic–radiologic rendezvous technique to treat the complete transection of the main bile duct, as it is possible to avoid difficult surgical reintervention that presents some morbidity and mortality.

Class IV injuries that involve a sectoral bile duct without transection of the duct can often be managed non-operatively, with drainage and stenting via either ERCP or PTC, with good outcomes in many cases.49–53 Class IV injuries involving transection of the bile ducts require reconstruction of the duct (either the RHD or a right sectoral duct) into a defunctionalized Roux limb.

With regard to reparative surgery, there are some basic rules, and the difficulty in repairing damage derives from both the size and caliber of the bile duct and from local inflammatory and sclerotic changes. The timing of the surgery is an extremely significant component in the repair of the lesion; consequently, an early detection of the lesion plays a key role. In case of partial or complete transection of the CBD, it is possible to execute a direct end-to-end suture if the distal choledochus is free and without strain. It is also ideal to protect the suture by inserting a Kehr T-tube, as shown in Figure 4. There is also a second type of T-tube available for biliary drainage, the so-called internal Y-drainage,54 which involves the insertion of the two short branches into both the right and left hepatic ducts, splinting of the anastomosis, and conducting of its long branch into the duodenum by the papilla of Vater. This tube can be removed endoscopically after healing of the end-to-end ductal anastomosis. Moreover, it was proposed as the drainage of choice in end-to-end ductal anastomosis.55–58 In case of impossibility to execute a direct suture or in cases of severe biliary strictures, a biliodigestive anastomosis is advised, a Roux-en-Y hepaticojejunostomy in most cases, as depicted in Figure 5. If a hepaticojejunostomy cannot be performed due to the presence of dense adhesions with infected and friable tissues, some authors have proposed a combination of endoscopic biliary stenting and pedicled omental patch repair of the bile duct to control bile leak and sepsis as a bridging procedure to definitive hepaticojejunostomy.59 In case of strictures involving the bifurcation or left or RHD, bilateral

hepaticojejunostomies may be necessary. For many years, biliary repair has been the prerogative of open surgery. Nowadays, the advancement in surgical technology has permitted to accomplish reconstruction of iatrogenic biliary lesions even via laparoscopic or robotic techniques with good outcomes.60–62 In a recent publication, Cuendis-Velázquez et al61 have proven that the robotic approach is similar to the laparoscopic technique for safety and efficacy in reaching primary patency of hepaticojejunostomy for bile duct reconstruction.

Liver resection is extremely rarely indicated in situations with severe hepatic necrosis. Liver transplantation may be necessary in a small subset of patients with iatrogenic BDIs if non-surgical or surgical management fails to alleviate acute or chronic liver failure.63

The Bismuth and Strasberg categories do not account for vascular injuries that occur simultaneously during LC. Class IV biliary injuries, according to the Stewart-Way system, often occur alongside lesions in the right hepatic artery. Hepatic abscess, hemobilia, and right hepatic lobe ischemia are symptoms that may accompany injuries to the right hepatic artery.64Hemobilia treatment, hepatic abscess drainage, and hepatectomy are all necessary procedures for many of these patients.65–68

In addition, many writers have examined the effects of biliary injuries on patients' quality of life. According to Flores-Rangel et al.69, patients who undergo bilioenteric derivation as a result of a biliary injury have a substantially lower quality of life compared to patients who undergo simple cholecystectomy, regardless of the surgeon's level of expertise. Furthermore, research by Booij et al.70 has examined the effects of BDIs on quality of life over the long term and has shown that these interventions significantly reduce patients' quality of life and impose limitations on their ability to do their jobs.

Conclusion

A major risk that might arise after cholecystectomy is iatrogenic BDIs. Misunderstanding the biliary anatomy is the primary cause of laparoscopic bile duct lesion mistakes. It would be really appreciated if there was an effort to lower the risk profile of routine cholecystectomy. Early diagnosis, management of intra-abdominal fluid collection and infection, nutritional balance, a multidisciplinary approach, and surgical repair by a skilled biliary reconstruction surgeon are the characteristics of effective treatment.

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