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Review Article

Iatrogenic bile duct injuries: diagnosis and management

Lesões iatrogênicas das vias biliares: diagnóstico e manejo

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ABSTRACT: Iatrogenic bile duct injury is a serious complication of surgical intervention in the gastrointestinal tract. Even in referral centers, the incidence of such injuries may vary from 0.2% to 1.5%. The incidence varies according to the choice of open surgery or videolaparoscopy and the severity of these injuries derives from the wide range of complications that can be caused, with a strong negative impact on the quality of life of the patient. Iatrogenic bile duct injuries were first classified in 1982 by Bismuth, and, with the advent of videolaparoscopy, various other classification systems were produced, that of Strasberg being one of the most widely used today. Diagnosis can be carried out with the aid of laboratory examinations and, principally, imaging technology, such as magnetic resonance cholangiopancreatography. Treatment presents a serious challenge for the surgeons and can be carried out using percutaneous endoscopic techniques and also surgery, the most common procedure being a Roux-en-Y hepaticojejunostomy. In patients with end-stage liver disease caused by secondary biliary cirrhosis, liver transplantation may be necessary. Whenever possible, the patient should be accompanied by a multidisciplinary team, and it is of paramount importance that such patients should be rapidly referred to a specialist center.

Keywords: Bile ducts; Cholecystectomy; General surgery.

RESUMO: A lesão iatrogênica das vias biliares (LIVB) se configura em uma grave complicação relacionada a abordagens cirúrgicas do trato gastrointestinal e mesmo em centros de referência taxas de 0,2% a 1,5% ainda são registradas. A taxa de LIVB varia se a cirurgia inicial foi realizada por meio de técnica aberta ou videolaparoscópica, e a sua gravidade se dá pelo grande espectro de complicações que podem ser causadas e que apresentam forte impacto negativo na qualidade de vida do paciente. A primeira classificação de LIVB se deu em 1982 com Bismuth e, com o advento da videolaparoscopia, várias outras foram feitas, sendo a de Strasberg uma das mais utilizadas até hoje. A suspeição diagnóstica pode ser feita com auxílio de exames laboratoriais e principalmente com exames de imagem, como a colangiorressonância. O tratamento se constitui em um verdadeiro desafio para a equipe cirúrgica e pode ser realizado por meio de técnicas percutâneas endoscópicas e também cirúrgicas, sendo mais comumente realizada por meio de hepaticojejunostomia em Y de Roux. No paciente com doença hepática em estágio terminal por cirrose biliar secundária, pode ser realizado o transplante hepático. O paciente sempre que possível deve ser acompanhado por uma equipe multidisciplinar e é de suma importância que seja rapidamente encaminhado para um centro especializado.

Palavras-chave: Ductos biliares; Colecistectomia; Cirurgia geral.

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INTRODUCTION

Iatrogenic bile duct injuries (IBDIs) are a serious complication of surgical interventions in the gastrointestinal tract and are most frequently caused by laparoscopic cholecystectomy, which is one of the most commonly performed surgical procedures in the world[1,2].

Even in referral centers, the rates of occurrence of bile duct injuries vary from 0.2% to 1.5%. This is worrying, because around 10% of the population have cholelithiasis and cholecystectomy is the most commonly performed elective abdominal procedure performed in the field of gastrointestinal surgery. In the United States, around 750,000 cholecystectomies are performed each year[3]. Injuries are often caused by the technical inexperience of the surgeons and normally occur within the first 100 procedures carried out[4,5,6,7].

It is extremely important to investigate the degree of damage done to the liver and to the bile duct at the time of reconstruction, and also the technique used to restore bile duct transit, since these factors are of great prognostic value. Injuries further up in the anatomy of the biliary tree have a major negative impact on the functional status of the liver and the survival of patients[4,8]. IBDIs are considered a severe complication because of the wide range of complications that may arise, and the clinical progression of the patient may involve jaundice, pruritus, recurrent cholangitis, and even secondary biliary cirrhosis, liver failure, and death[1,6].

OBJECTIVES

Main Objective: To conduct a review of the literature on the main points relating to iatrogenic biliary injuries, examining the various ways of diagnosing and treating such injuries.

Specific Objectives: To demonstrate ways of diagnosing injuries, both intra- and postoperatively.

To assess ways of managing and treating patients subsequent to the occurrence of injuries, in accordance with the specific individual features of each case.

METHODOLOGY

A review of the literature was conducted using the search term "iatrogenic bile duct injury" in the MEDLINE (Literatura Internacional em Ciências da Saúde), PubMed and LILACS (Literatura Latino-americana em Ciências da Saúde) databases for publications dating from 2004 to 2022, written in English or Portuguese. Inclusion criteria were then established for study selection: articles with the full text available for reading were assessed using the following inclusion and exclusion criteria. The inclusion criteria were: (1) written in English or Portuguese, (2) relevant to the topic, (3) involving a surgical procedure, including liver transplantation. Articles were excluded if they did not meet the inclusion criteria.

HISTORY

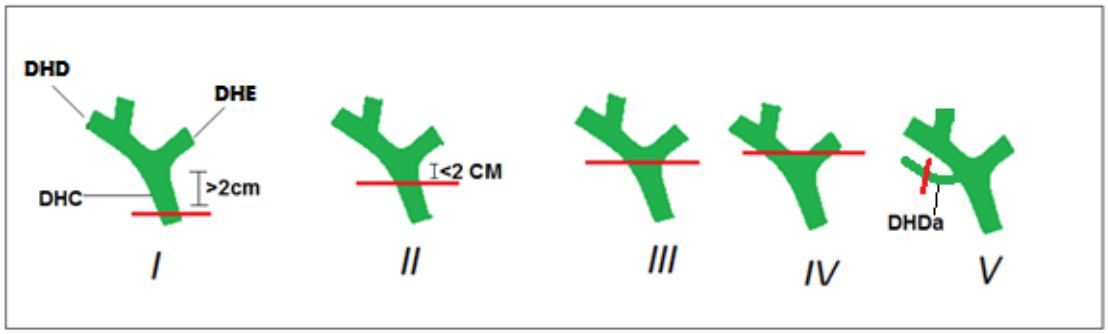
There is evidence of knowledge of the anatomy of the liver and bile ducts going back to Ancient Babylon, around 2000 BCE. Bile duct procedures are also very ancient, the first gallbladder calculi having been removed in 1618, the first cholecystostomy performed in 1878 and the first cholecystectomy in 1882. Naturally, procedures involving the bile duct also caused some injuries. The first recorded IBDI was described in 1891 by Sprengel, and the first Roux-en-Y hepaticojejunostomy to correct this condition was performed by Dahl in 1909. Videolaparoscopic cholecystecomy was first performed by Phillipe Mouret in 1987 and has since been adopted as the gold standard[1].

CLASSIFICATION

In the period when open surgery was used to perform cholecystectomy, bile duct injuries were categorized using the Bismuth Classification (Table 1). As the availability of videolaparoscopy grew and it became the gold standard for cholecystectomy, this classification was modified by Strasberg, who added some kinds of injury more common in videolaparoscopic surgery. This system is still widely used today (Table 1)[2,3].

Table 1: Bismuth and Strasberg Classification.

Injury	Classification
Leak in the cystic duct or small ducts in liver bed	Strasberg:A / Bismuth: -
Occlusion of an aberrant right hepatic duct	Strasberg B/ Bismuth: -
Transection without ligation of aberrant right hepatic duct	Strasberg C/ Bismuth: -
Lateral injury to common hepatic duct or bile duct (<50% circumference)	Strasberg D/ Bismuth: -
Circumference injury of common hepatic duct, stump >2cm	Strasberg: E1/ Bismuth: type 1
Circumference injury of common hepatic duct, stump <2cm	Strasberg: E2/ Bismuth: type 2
Circumference injury of hilus, with preserved biliary confluence	Strasberg: E3/ Bismuth: type 3
Circumference injury of hilus, with loss of confluence	Strasberg: E4/ Bismuth: type 4
Combined injury of aberrant right hepatic duct and circumference injury of hilus	Strasberg: E5/ Bismuth: type 5



Key: CHD: common hepatic duct; LHD: left hepatic duct; RHD: right hepatic duct; aRHD: accessory right hepatic duct

Figure 1: Bismuth Classification, the first to characterize IBDIs.

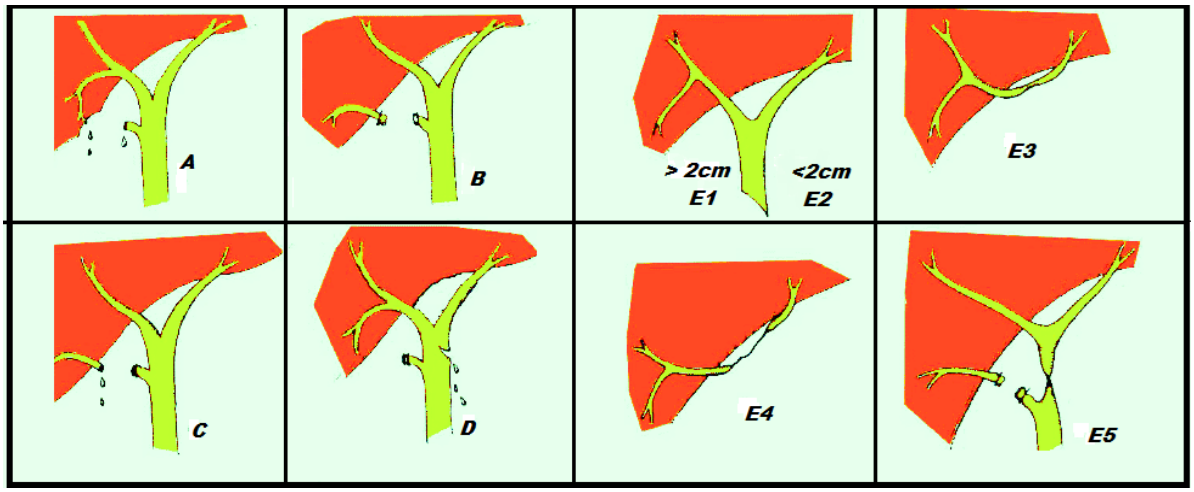


Figure 2: Strasberg Classification (Adapted from Strasberg SM, Hertl M, Soper NJ. An analysis of the problem of biliary injury during laparoscopic cholecystectomy. J Am Coll Surg 1995; 180:105)

Another more detailed classification is Stewart-Way, which addresses the mechanisms underlying the bile duct injury and its anatomy. These are divided into four classes: Class I, accounting for 6% of cases, includes incisions in the main bile duct, without loss of this organ; Class II, covering 24% of cases, covers lateral injuries of the hepatic duct, resulting in a leak or stricture, normally caused by the use of clips or cautery to attempt to stop bleeding in Calot's triangle; Class III, which is the most common, accounting for 60% of cases, covers cases of transection or excision of a variable length of the bile duct, normally including the junction between the cystic and bile ducts; and, finally, Class IV represents 10% of cases and includes injuries to, or transection of, the right hepatic duct, these being generally associated with damage to the right hepatic artery. It is worth noting that Classes II and III are further subdivided according to the degree of injury[3,9].

In view of the complexity of IBDIs, over time, a series of classifications other than the ones cited above have been produced. These include those developed by McMahon, Nehaus, and Hannover. McMahon classifies the size of the bile duct injury, dividing these into minor injuries (lacerations that affect less than 25% of the diameter of the common bile duct or the cystic duct-common bile duct junction) and major injuries (transections or lacerations affecting more than 25% of the common bile duct and involving post-operative stricture of the bile duct). The Nehaus classification, meanwhile, distinguishes between different patterns of injury and also includes long-term recurrence of cholangitis. The Hannover classification, different from its precursors, distinguishes between tangential injuries and those involving transection, both in the bifurcation of the hepatic duct and above it, and also outlines other details of the injury[10].

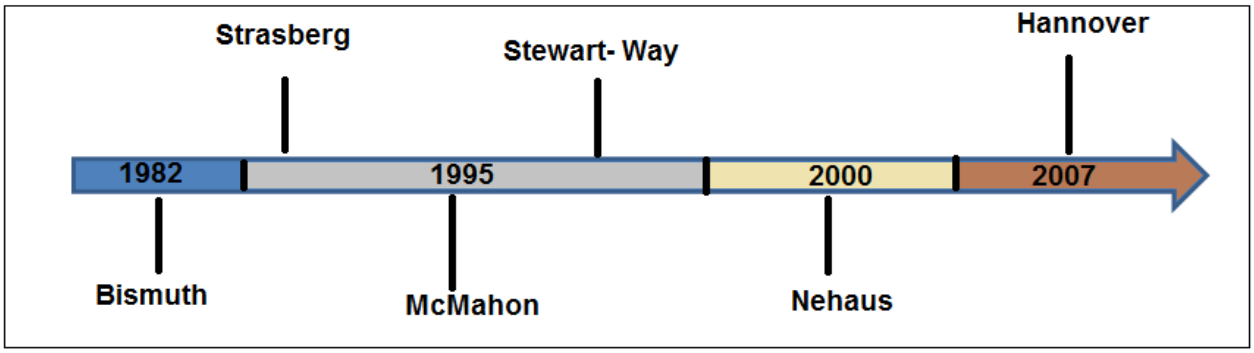


Figure 3: Timeline of IBDI classifications. With the advent of laparoscopy and its evolution, an attempt has increasingly been made to produce classifications that address and characterize IBDIs with the greatest possible complexity and richness of detail.

CLINICAL PRESENTATION

The clinical profile of patients varies, depending principally on the type of injury, the time taken to diagnose it, and the presence of complications. IBDIs may be diagnosed intraoperatively or may manifest themselves days, months or even years after the initial surgery[11].

The patient may, in the postoperative period, present with jaundice, biliary peritonitis, cholangitis, in addition to non-specific symptoms, such as abdominal pain, nausea, vomiting and anorexia[1,5,11]. Symptoms will vary if the patient presents with leakage of bile into the cavity, most commonly accompanied by fever, abdominal pain, and signs of sepsis, or cicatricial stricture of the biliary system, of which cholestasis is a major sign[1]. Late manifestations may include recurrent cholangitis and secondary biliary cirrhosis[11].

DIAGNOSIS

Diagnosis of IBDI during a cholecystectomy is difficult and this occurs in only 25% of cases in most studies[3,9]. This difficulty of intraoperative diagnosis has, however, given rise to a study examining the use of intraoperative cholangiography under two scenarios: in the first, as a routine procedure; and, in the second, employed selectively based on certain criteria. The study found that routine early use of this procedure for diagnosis of IBDI produces fairly positive results, with a detection rate of around 90%, while, when used selectively, the rate of detection of injuries varied between 20 and 30%, much lower than when routinely used.[12] Furthermore, a number of issues are of great anatomical importance during the procedure. These include noting that the common bile duct is located medially in relation to the gallbladder and that the right hepatic artery passes posterior to the common bile duct in 80% to 90% of cases[3].

In relation to diagnosis during surgery, the following factors may suggest IBDI: drainage of bile through ducts or from locations other than the gallbladder under dissection, a large-caliber cystic duct (which may be the common bile duct), significant hemorrhage or inflammation, identification of an accessory bile duct or some other tubular structure, among others. For this reason, the surgeon should promptly identify and treat injuries during the procedure[3].

Laboratory blood tests for bilirubin, alkaline phosphatase, gamma glutamyl transferase and transaminases may be useful for diagnosis and follow-up of patients with IBDIs. In patients without serious complications, there is no injury to the liver and normally only laboratory examinations indicative of cholestasis show alterations, with no pronounced increase in aminotransferases. High levels of the latter suggest the presence of vascular injury and are more indicative of progression to secondary biliary cirrhosis[1].

In relation to image diagnosis, computerized tomography and ultrasonography possess some limitations, being restricted to detection of dilation of the biliary ducts and perihepatic collections, including free bile in the abdominal cavity[1,3,13,14]. Retrograde endoscopic cholangiopancreatography can also be used in selected cases, since, in addition to study of the biliary tract, this makes it possible to carry out interventions in smaller bile ducts, by way placing prostheses. This however has significant disadvantages, including the fact that it is an invasive procedure with a high risk of complications, such as intraluminal bleeding and sepsis[11,14]. Magnetic resonance cholangiography would appear to be the best option, because it is a non-invasive procedure with a sensitivity of 85%-100% and is thus considered the gold standard for pre-operative treatment of patients with IBDI[1]. One highly promising technique is magnetic resonance cholangiography using gadoxetic acid as a liver-specific contrast medium. This technique has been shown to be useful in revealing the anatomy of the biliary tree both before and after surgery and also in detecting and characterizing biliary diseases and complications of surgery, including calculi, strictures, leaks, and biliary cysts. It is also capable of providing functional information,

for which reason it is sometimes also called functional magnetic resonance cholangiography. The aim of this is to grade biliary strictures and to evaluate bile flow dynamics and segmental liver function.[14] Furthermore, intraoperative X-ray cholangiography may also be capable of helping to identify an IBDI at the time of surgery. However, since this presents a number of disadvantages, such as lengthening the duration of surgery and increasing costs, use of this technique still requires further investigation[7].

LAPAROTOMY vs. VIDEOLAPAROSCOPY

The incidence of IBDI varies depending on whether the initial procedure was open surgery or videolaparoscopy. There is much discussion in the current literature as to the type of procedure that might cause a higher incidence of IBDIs. Some studies have indicated that videolaparoscopic cholecystectomy is a safe and effective procedure compared to open surgery[15,16]. A study conducted by Fortunato et al. involved a total of 515 cholecystectomies, of which 320 were laparotomic and 195 videolaparoscopic. No procedure in which the minimally invasive approach was adopted resulted in an IBDI, while there were 4 cases of IBDI among those patients who underwent open surgery (1.25%). This led these authors to conclude that the videolaparoscopic approach has a lower incidence of IBDI and is a safe procedure[15].

On the other hand, more recent studies have shown that, with the laparoscopic technique being used more generally, there has been an increase in the incidence of IBDI, and that the current rate in fact varies between around 0.2 and 1.5%[7]. This results from the fact that the learning curve for video surgery is longer and that medical residents and inexperienced surgeons are primarily the ones responsible for causing these kinds of injuries.[2,4] In an effort to change this, new techniques are being developed that aim to further reduce the occurrence of IBDIs. These include use of fluorescent colorings, such as indocyanine green, which are excreted in the bile and enhance visualization of biliary structures. Further research, however, is required to determine when these might best be indicated, the appropriate dose, time, and optimal method of administration[7].

Another videolaparoscopic technique that is being widely studied for practical application is robot-assisted surgery. However, one study of patients undergoing this technique found proportionally more complications, a higher incidence of conversion to open surgery, more re-admissions, and more bile duct injuries, with, in the case of this last criterion, the group undergoing robot-assisted surgery experiencing an incidence of 1.3%, compared to 0.4% for traditional laparoscopy[17].

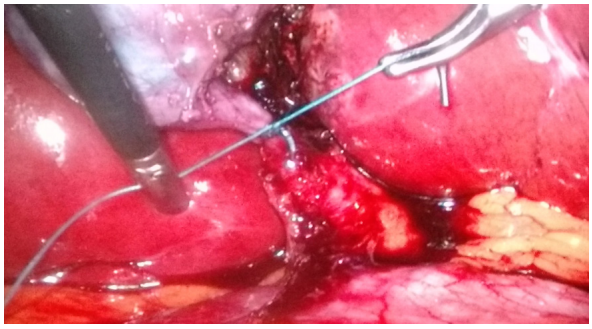


Figure 4: Videolaparoscopic view of ligation of cystic duct.

TREATMENT

Treatment of IBDIs presents a real challenge for surgical teams and is critical for patients, since such injuries may have consequences such as secondary biliary cirrhosis, liver failure, and even death. The main factors determining the prognosis for the patient are the location of the IBDI and the quality of the duct proximal to the stricture, the liver functioning of the patient, and the level of experience of the surgical team involved.[18]

In pre-operative evaluation, it is of paramount importance that an imaging examination be carried out (preferably cholangiography or magnetic resonance), to provide the team with better understanding of the injury[3,19].

It is worth pointing out that, in managing IBDIs, endoscopic techniques, interventional radiology, and surgery all complement one another and are not mutually exclusive[9]. In some cases, treatment involving endoscopic techniques and percutaneous access may be useful in managing IBDIs as a first approach. In other selected cases, such as recanalization of the bile duct, it is technically possible and safe to employ a multidisciplinary combination of percutaneous and endoscopic techniques[1,10,13,20]. In cases involving percutaneous access, the techniques used may involve stent placement or balloon dilation. The latter is around 52% effective, while the effectiveness of the stent placement varies from 40% to 80%. Retrograde endoscopic cholangiopancreatography can also be used and has a success rate of around 72%, having been shown to be considerably effective in cases of bile leakage following cholecystectomy[1,13]. These procedures are not without complications and there are reports in the literature of sepsis, cholangitis and hemobilia occurring as a result of percutaneous procedures[1,10,13]. Retrograde endoscopic cholangiopancreatography may give rise to cholangitis, pancreatitis, sepsis, and other complications[1,14]. It is however important to note that surgical treatment is indispensable when dealing with cases of Strasberg's Type E4 or Type E5 injuries[9].

Surgical treatment of IBDIs requires highly

experienced teams, since, when treated by the surgeon who caused them, the failure rate of surgical repair is greater, with success rates varying between 17% and 30%.[10,19,21] It is thus almost unanimously agreed in the international literature that a surgical procedure to repair an IBDI should be carried out by surgeons experienced in this procedure. It is also important to note the existence of series in which the success rate of surgery exceeds 90% when carried out by surgeons such as these. This practice also leads to shorter stays in hospital for patients[3,19,21,22]. Important factors related to the success of the surgery include: elimination of intra-abdominal infection and inflammation, single-layer anastomosis using healthy bile duct tissue, tension-free anastomoses using monofilament absorbable suture[3,9].

The basic principle underlying surgical repair of IBDI involves allowing bile to pass from the biliary system into the digestive tract. Various surgical techniques described in the literature can be used for this, including main biliary system end-to-end anastomosis, Roux-en-Y hepaticojejunostomy, choledochoduodenostomy and Blumgart anastomosis (Hepp). Of these techniques and others, Roux-en-Y hepaticojejunostomy is, however, the one that is most widely described in the literature and the one that has the highest rate of success[1,18].

Roux-en-Y hepaticojejunostomy reconstruction involves identification of the most viable portion of the common hepatic duct and a ligation being performed in the distal portion of the main bile duct. Then, an end-to-side or end-to-end anastomosis with the jejunum is created, using a single-layer suture. Two drawbacks of this surgical technique that should be borne in mind concern the risk of anastomotic stricture and also the non-physiological route of the bile through the digestive tract. The latter occurs as a result of the absence of bile passing through the duodenum and through the initial part of the jejunum, causing a series of alterations in hormone secretion, which may lead to poor digestion and absorption and even increase the likelihood of the appearance of a duodenal ulcer as a result of anomalous release of gastrin[1,18,23].

Choledochal-duodenal anastomosis, despite being a physiological solution and one that is easier to perform than the aforementioned procedures, is indicated only in some cases, such as those involving injuries to the distal common bile duct. In addition to the higher risk of stricture, there is also the possibility of bile reflux, causing recurrent cholangitis and increasing the risk of neoplasia[1,18].

Subsequent to the procedure, it is advisable to place a drain to ensure that the anastomosis is as successful as possible. A (Kehr) T drain, a Y drain, or some other can be used. The drain is believed to act to reduce the occurrence of fibrosis and inflammation. There is, however, no consensus as to how long the drain should remain in place nor even as to whether it is effective, although some studies suggest that use for at least six months may be beneficial to the patient in the postoperative period[1,23].

Strasberg's type E4 injury is one of the greatest technical challenges facing a surgeon, because of the loss of confluence of the hepatic ducts. In a small number of cases, the occurrence of such injuries is facilitated by the fact that the patient presents anatomical variations, with very low confluence of the hepatic ducts. This kind of injury may occur as a result of various mechanisms, including during dissection and even as a result of the placement of drains in the common duct for a prolonged period of time. Treatment requires experience on the part of the surgeon and should be specific to each patient. Various techniques can be employed, including the creation of a portoenterostomy or, preferably, a neoconfluence[24].

One study aiming to modify interventions carried out in cases of Strasberg-Bismuth IBDI types E1-4 presented a biliary anastomosis technique known as fish-mouth-shaped biliary-biliary end-to-end reconstruction, which possesses some advantages in relation to other techniques currently in use, including the fact that it preserves normal functioning of the sphincter of Oddi and approximates as closely as possible to the physiological trajectory. Another point in favor of this technique is the fact that remodeling the ends of the bile duct in the shape of a fish mouth facilitates the anastomosis by creating a wider stoma and thus relieving subsequent biliary stricture. It is also important to note that numerous observations have been made regarding how to reduce the failure rate of surgery. These include the placement of a T drain to provide support for the bile duct for at least six months[23].

The incidence of vascular injury associated with iatrogenic injury to the principal biliary system is not well established but may vary between 12% and 61% of cases. A wait-and-see approach can be adopted for some of these patients, but some cases will invariably require surgical repair. [25] For patients who present with somewhat complex IBDIs, involving vascular injuries, another treatment option is hepatectomy, although this is rarely performed.[8,25,26] Cases in which this course of action is indicated can be divided into two groups related to the timing of the cholecystectomy: early or late. In the former, which covers the immediate postoperative period, hepatectomy may be carried out in cases of hepatic necrosis, abscesses, and leakage of bile, for the purpose of controlling the occurrence of sepsis and peritonitis. In the other group, hepatectomy is performed in patients who present with recurrent cholangitis despite conventional treatments already having been carried out, and also in cases of symptomatic lobar atrophy[26].

Some studies underline the importance of rapid referral to large specialist center. One has shown that, of a total of 300 liver transplantations carried out, only five (1.7%) were due to IBDIs. Liver transplantation is often the last option for patients with end-stage liver disease, but the procedure is also associated with high rates of mortality and morbidity, in view of the complexity of the surgery and the serious nature of the patient's condition[27,28].

In cases of liver transplantation, it should be noted that, in this case, the MELD score is not a good tool, since its assessment of liver functioning is well-established only for use in patients with hepatic cirrhosis. In the case of secondary biliary cirrhosis caused by IBDI, there is still no tool analogous to the MELD for evaluation of such patients[29].

Finally, it should be remarked that, to achieve the best possible outcome, treatment should, whenever possible, be carried out within an appropriate time frame by a multidisciplinary team including a gastroenterologist, a radiologist and a surgeon[28,30]. The surgeon should be aware that a cholecystectomy always poses a risk, however small, of IBDI, and it is therefore of paramount importance that the patient also be cognizant of this, in view of the significant reduction in quality of life and irreversible consequences that an IBDI may cause. Failure to clarify these issues further increases the risk of conflict between patient and physician and the likelihood of lawsuits being filed[31,32].

CONCLUSION

IBDI is a serious complication that may occur during cholecystectomy and, to reduce the risk of injury, surgeons should always be aware of the anatomy of the biliary tree prior to ligature and cauterization of these structures. Once it has been established that a patient has an IBDI, information about the injury should rapidly be sought and the patient referred to the nearest appropriate specialization center, since delay can cause serious complications and have a significant detrimental impact on the patient's quality of life.

Authors' contributions: *Olival Cirilo Lucena da Fonseca Neto* conducted bibliographical research, corrected and edited the final manuscript and provided supervision. *Mateus Interaminense Perez* conducted bibliographical research and contributed to the writing of the Abstract, the Introduction, the Objectives, Methodology, History, Classification, Clinical Presentation, Diagnosis, Laparotomy vs. Videolaparoscopy, and Treatment sections, and the Conclusion. *Vladmir Goldstein de Paula Lopes* conducted bibliographical research and contributed to the writing of the Abstract, the Introduction, the Objectives, Methodology, History, Classification, Clinical Presentation, Diagnosis, Laparotomy vs. Videolaparoscopy, and Treatment sections, and the Conclusion.

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