

Surgical therapies for iatrogenic bile duct lesions (IBDL) – review

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ABSTRACT

The article is a review of the surgical therapies for iatrogenic bile duct lesions (IBDL). The history of the bile duct surgical procedures starts in 1882, when the first cholecystectomy is performed. There are several classifications of the IBDLs such as Bismuth, Wood et al., McMahan et al., Strasberg et al., Bergman et al., Bismuth and Majno, Stewart-Way, Hannover and Mattox. The choice of the proper surgical treatment of IBDLs depends of their type and the review describes the end-to-end repair, hepaticojejunostomy, hepaticojejunostomy without sutures, mucosal graft (Rodney Smith technique), hepaticoduodenostomy, Heineke-Mikulicz plastic repair of stricture, right and left duct hepaticojejunostomy, construction of hepatic duct bifurcation when bifurcation has been destroyed, intrahepatic cholangiojejunostomy, ligamentum teres (round ligament) approach to the left hepatic duct and Longmire procedure. Even the surgical treatment of IBDLs is in continuous development and research, their best prevention is the proper training of the biliary surgeons in the performance of safe cholecystectomies or any other abdominal surgeries, complex gastrotomies, pancreatic operations, endoscopic biliary tract investigations etc.

Keywords: bile duct, strictures, anastomosis, cholecystectomy, iatrogenic bile duct lesions, hepaticojejunostomy, cholangiojejunostomy

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INTRODUCTION

The possibility of the inadvertent injuries during surgeries appeared once the surgical procedures developed. The field of iatrogenic treatment is getting more complex and the need of treatment classifications is crucial for both research and surgical practice.

History

The German Langenbuch performed the first planned medical cholecystectomy in history in 1882 and was followed by Kappler's suggestion of 1887 that the anastomosis should be made by a mucosa-to-mucosa apposition and the use of a stent mentioned by Terrier in 1892. Also in 1892, Loyen described the first choledo-chooduodenostomy for calculi and, in 1897, Roux describes the Roux-en-Y anastomosis of the small intestine. The Kocher procedure appears in research in 1903 followed by the first reconstruction of the biliary tract to repair the damage occurred during a routine cholecystectomy described by Mayo in 1905. In the same year, Keher performs an end-to-side choledo-chooduodenostomy. In 1924 are introduced the procedures of dissection and anastomosis of fistulous tracts. In 1948, Longmire and Stanford describe the maneuver of finding a branch of the left hepatic duct for anastomosis and in 1952 the PTC is reported (percutaneous transhepatic cholangiography). In 1956 Couinaud describes the hilar plate and the log extrahepatic course of the left hepatic tube that leads to important procedures of the stricture repair. Thomford and Hallenbeck, in 1965 propose a cutaneous stoma for the Roux-en-Y loop of jejunum, used in hepaticojejunostomy (HJ). Mc Cune and Oi report the use of duodenal endoscopy in retrograde cholangiopancreatography (ERCP) in 1968 and 1970. 1979, through Northover and Terblanche, brings the important discovery that the arterial supply to the bile duct is syncytial and arises from longitudinal arteries on either side of the duct and from hepatic and gastrointestinal arteries so surgeons must produce a duct length on one-layer anastomosis of 2 mm (1).

The iatrogenic bile duct lesions are recorded during open cholecystectomy (OC) or laparoscopic cholecystectomy (LC), the last procedure being introduced in medicine in 1987 by Mouret (2). Currently, cholecystectomy is the most common abdominal surgery in the world.

Anatomy and histology

The bile duct cyst is histologically divided into mucosa, stroma and adventitia. Its wall has con-

nective tissue rich in elastic fibers, that contain scattered myofibroblasts. The sparse muscular fibers do not form a defined muscular layer. Near the Vater papilla, there can be observed scattered smooth muscle cells (3).

ETIOLOGY AND PATHOGENESIS OF IATROGENIC BILE DUCT LESIONS (IBDL)

The IBDLs can be classified as a) postcholecystectomy bile duct lesions or b) lesions resulted after other abdominal surgeries. The first class of injuries arise during laparoscopic (LC) or open cholecystectomies (OC). Many iatrogenic injuries stay unknown until they cause complications due to stricture formation (4). After OCs, strictures are found mostly in the common bile duct (CBD) and they result due to the "surgical inexperience, failure to recognize abnormal biliary anatomy and congenital anomalies, acute inflammation, misplacement of clips, excessive use of cautery and excessive dissection around the major bile ducts resulting in ischemic injuries" (5). The after LCs strictures are short and occur normally in the common hepatic duct, distal to the confluence of the right and left hepatic ducts. The second category usually occurs after most gastrotomies and hepatic resections. During gastrotomy, the most common injury involves the dissection of the pyloric region and the first portion of the duodenum in face of acute and chronic inflammation of peptic ulcer and for gastric cancer. Injuries during liver resections occur due to the small distance between the tumor and hilum, causing the damage of the biliary tree.

LOCATION AND CLASSIFICATION OF IBDLS (6)

Bismuth classification of benign bile duct strictures based in the anatomic pattern of involvement (1982) – 5 types:

- Type 1 – hepatic duct stump > 2 cm;
- Type 2 – hepatic duct stump < 2 cm;
- Type 3 – no hepatic duct, confluence intact;
- Type 4 – destruction of hilar confluence;
- Type 5 – right sectorial duct injury, with or without common hepatic duct injury.

The classification does not take into account the bile leaks and it cannot be used for all injuries to select a treatment, especially not for bile leaks after LC or for patients with limited stenosis.

Woods et al. classification based on biliary injury as a complication of LC (1994):

Group 1 – cystic duct leaks (which are in fact not true bile duct injuries);

Group 2 – major bile duct leaks and/or strictures;

Group 3 – major ductal transections or excisions.

McMahon et al. classification (1995) – major and minor bile duct injuries.

Strasberg et al. classification (Types A-E) (1995) – including sub-classifications for treatments (E1-E5) according to Bismuth:

Type A injury – bile leaks from minor duct of from “Lushka’s tubules” with the common bile duct;

Type B injury – involves occlusion of part of biliary tree which for practical purposes usually aberrant right sectorial hepatic duct;

Type C injury – leaks from duct not in communication with common bile duct;

Type D injury – lateral injury to the extrahepatic bile ducts;

Type E injury – circumferential injury of major bile ducts (Bismuth class 1 to 5).

E1 – transection of more than 2 cm from the confluence of extrahepatic bile ducts;

E2 – transection of the less than 2 cm from the confluence;

E3 – transection of the liver hilum of both hepatic ducts;

E4 – transection in the liver hilum over the confluence of both hepatic ducts;

E5 – Type C plus damage of ductus choledochus (7)

Bergman et al. classification (1996) – where the IBDs are defined as damages to the biliary system, so 4 types of IBDs can be identified

Type A – cystic duct leaks or leakage from aberrant or peripheral hepatic ducts including the so-called duct of Luschka;

Type B – major bile duct injuries with or without concomitant biliary strictures;

Type C – bile duct strictures without bile leakage;

Type D – complete transection of the bile duct with or without excision of a part of the bile duct.

Bismuth and Majno classification (2001) – based on the lowest level at which healthy biliary mucosa is available for anastomosis

Type I strictures – with a common duct stump longer than 2 cm, can be repaired without opening the left duct and without lowering the hilar plate.

Type II strictures – with a common duct stump shorter than 2 cm, require opening the left duct for a satisfactory anastomosis. Lowering the hilar plate is not always necessary but may improve the exposure.

Type III strictures – in which only the ceiling of the biliary confluence is intact, require lowering the hilar plate and anastomosis on the left ductal system. There is no need to open the right duct if the communication between the ducts is wide.

Type IV strictures – the biliary confluence is interrupted and requires either reconstruction or two or more anastomosis.

Type V strictures – strictures of the hepatic duct associated with a stricture on a separate right branch, and the branch must be included in the repair.

Stewart-Way classification (2007) (8)

Class I injury – occurs when CBD is mistaken for the cystic duct, but the error is recognized before CBD is divided.

Class II injuries – involve damage to CHD from clips or cautery used too close to the duct. This often occurs in cases where visibility is limited due to inflammation or bleeding.

Class III injury – the most common type, occurs when CBD is mistaken for the cystic duct. The common duct is transected and a variable portion including the junction of the cystic and common duct is excised or removed.

Class IV injuries – involve damage to the right hepatic duct (RHD), either because this structure is mistaken for the cystic duct, or because it is injured during dissection. Both complex bile duct and vascular injuries were included in the Stewart-Way classification.

Hannover classification (9)

Bektas et al. proposed a new classification system named Hannover classification after comparing the classification of bile duct injury for consecutive 72 iatrogenic bile injuries after laparoscopic cholecystectomy. In the Hannover, bile duct injuries were divided into five types from A to E.

Type A – peripheral bile leakage;

Type B – stricture of CHD or CBD without injury;

Type C – lateral CHD or CBD injury;

Type D – total transection of CHD;

Type E – bile duct stricture of the main bile duct without bile leakage at postoperative state.

Vascular injuries are included in Type C and Type D.

Mattox classification (1996) (10)

The Mattox classification of IBDIs takes into consideration the types of injuring factors (contusion, laceration, perforation, transection, diversion or interruption of the bile duct or the gallbladder).

The main risk factors in postoperative IBDL are divided in 3 great categories: dangerous anatomy, dangerous pathologic findings and dangerous surgery. As dangerous anatomy can be mentioned the conditions in which the right hepatic duct inserts low in the common duct, the cystic duct runs parallel to the common one or spirals to enter the bile duct on the medial surface. The dangerous findings can be considered: acute or gangrenous or perforated cholecystitis, polycystic disease of the liver, hepatic cirrhosis, scleroatrophic gallbladder and Mirizzi's syndrome (11). Within the dangerous surgeries we can mention: dissection lesions, hemostasis, thermal and laser lesions and retraction lesions.

TREATMENT METHODS OF IBDLS

The management of postoperative bile duct strictures and major bile duct injuries remains a challenge for even most skilled biliary tract surgeon (12).

The operative strategy of surgical reconstruction of the IBDLs has four steps:

- (a) discovery of the biliary remnant;
- (b) identification of the complete ductal system;
- (c) preparation of the intestinal conduit;
- (d) biliary–enteric anastomosis.

The first two take most of the time, require most patience, and are the most crucial to the quality of anastomosis and long-term outcome (13).

Non-surgical techniques for IBDLs treatment

1. *US guided drainage*: the cases with suspected biliary leakage are treated by US guided drainage using 20 Fr. Nelaton tube under local infiltration anesthesia.
2. *Endoscopic retrograde cholangiopancreatography (ERCP)*: the cases with biliary leaks (fistula) are subjected to therapeutic ERCP (14).

Surgery techniques of reconstruction and repair of IBDL

As preoperative measures before surgical procedures there can be mentioned the antibiotic coverage, IV fluids and parenteral vitamin K and

plasma or human albumin if needed to correct any coagulopathy or hypoalbuminemia (14).

1. End-to-end repair: is a type of reconstruction procedure that consists of the mobilization of the duodenum with the pancreatic head using the Kocher technique. Afterwards, the bile duct stricture is excised and the proximal and distal stumps are refreshed. This type of reconstruction, using a T-tube allows a minimal loss of bile duct tissue so the surgeon can use a long enough extrahepatic bile duct that permits a tension-free mucosa-to-mucosa anastomosis. The anastomosis is performed in a single layer with interrupted absorbable PDS 4-0 or 5-0 sutures and the T-tube is inserted in the CBD (15). The injured bile duct is resected back to the healthy tissue. End-to-end repair has a high failure rate, with late stenosis and/or dysfunctional consequent to loss of substance from the duct and ischemia secondary to the dissection (16).

2. Hepaticojejunostomy (HJ): is the most common treatment of IBDLs. The repair of the extrahepatic biliary tract lesions through HJ is performed using direct sutured anastomosis between the bile duct and the Roux-en-Y loop of jejunum at a level of good blood supply and remains the main standard for treatment of IBDLs and strictures (17). The technique aims to a tension free mucosa-to-mucosa anastomosis of an adequate diameter. The end-to-side procedure on the common hepatic duct can be used on the Bismuth type 1 and 2 injuries. The Bismuth type 3 and 4 are repaired using the extrahepatic portion of the left hepatic duct after the hilar plate has been lowered by blunt dissection (18). A study from 2016 mentions "the temporary trans-jejunal stenting of the hepatic ducts that help maintaining the integrity of anastomosis without stenosis or biliary sepsis. No instance of anastomotic leakage or stenosis, biliary sepsis, thromboembolic event, or respiratory infection was noted in the long-term follow-up. The outcome was excellent in all patients. No case with poor or failure of result was noticed" (19).

3. Hepaticojejunostomy without sutures: The technique is a new version of the HJ procedure and was introduced in practice by Bratucu et al. (20). It is indicated for patients showing benign stenosis of the common bile duct. The procedure consists of the anastomosis of the segments without using sutures, the same effect being obtained by simply keeping them in apposition with continuous traction exerted via a Foley-type balloon

catheter which stents the anastomosis in an axial manner. The balloon is then inflated and traction is exerted on the catheter, enabling the two segments of the anastomosis to remain in place until complete healing (10 days average) (5).

4. Mucosal graft (Rodney Smith technique):

The procedure was described in 1969 and is less used in cases where mucosa-to mucosa can be performed. It was used for high biliary strictures, but too high for a sutured HJ. This technique does not admit the access to the extrahepatic part of the left hepatic duct and is not commonly recommended due to its high resticture. The procedure consists of the suturing of the jejunum to a transhepatic tube and pulling the least so that the liver's hilum reaches the jejunum. Sutures are made between the serosa and the liver's capsule (21).

5. Hepaticoduodenostomy: The procedure has good results when used for patients in which the right upper quadrant cannot be reached through the Roux-en-Y limb, being performed in the end-to-side technique, the endoscopic instrumentations having easy access to the anastomosis (16). The risk of the procedure consists of a difficult to treat defect in the side of the duodenum in the situations when the duodenum is used and a second procedure is needed (14).

6. Heineke-Mikulicz plastic repair of stricture: a longitudinal incision is done through the stricture then transverse closure is done and a T-tube stent is used (22).

7. Right and left duct HJ: consists of the performance of two HJ procedures. The technique is used in the case of distant hepatic ducts that are impossible to be stented with only one T-tube so is indicated the use of two separate transhepatic tubes (23).

8. Construction of hepatic duct bifurcation when bifurcation has been destroyed: the standard procedure stands of the approximation of the right and left hepatic ducts in order to create a new septum. This can be crushed with a thin hemostat, creating a new common hepatic duct or an extension of the bile duct opening going to the left hepatic duct, so a wide anastomosis. Due to this procedure, a single anastomosis is performed (9).

9. Intrahepatic cholangiojejunostomy (CJ): the procedure is rarely used, in the cases of pa-

tients with multiple hilar operations history, and whose hilum is not accessible or is frozen and replaces the Longmire procedure. CJ procedures are complex and are recommended for experienced hepatobiliary surgeons. The procedure consists of either the drainage of the liver's left lobe through the duct segment III or of the right lobe through segment V. The duct's segment III is located on the left side of the round ligament (24).

Another intrahepatic reconstruction technique, recommended by Mercado et al. for the reconstruction of the biliary tree after complex high injuries, is the removal at the hilar plate level of a segment IV slice. The procedure implies the removal of thin slices of segment IV, between the gallbladder bed and round ligament, until the left and right ducts are exposed. Once the ducts are exposed, the follow-up can be fulfilled, the patient having a good quality of life and no restenosis (25).

10. Ligamentum teres (round ligament) approach to the left hepatic duct: Dense adhesions can cause the lack of exposure of the hepatic duct located beneath the quadrate lobe. The procedure consists of the dissection started to the left, at the base of the ligamentum teres, this one being elevated and the liver's bridge joining segment IV to the left (26).

11. Longmire procedure: consists of the excision of a part of the liver's left lobe in order to identify a dilated duct. Research show that this procedure is associated with a greater blood loss and often less effective biliary enteric anastomosis (9).

The postoperative treatment of the IBDLs stands of providing parenteral fluid but stopped when the patient starts on oral fluid, antibiotic for 5 – 7 days covering gram negative and anaerobic bacteria and care of the drains.

The follow-up of the patients includes the clinical assessment on symptoms of jaundice, cholangitis, pruritus, dark urine, pale stools, symptoms suggestive of biliary leakage and hepatic cell failure (14).

RESEARCH PERSPECTIVES IN THE TREATMENT OF IBDLS

One of the experimental non-surgical treatment methods of post-operative care, performed in Brazil, is the use of tamoxifen (tmx) on the fibrosis, the collagen and the transforming growth factor TGF- β 1, - β 2 and - β 3 in the anastomose of the CBD, performed on pigs. The results show that

the txm decreased the fibrosis and stopped the alteration in the type I / III of collagen proportion caused by the procedure. These data proves that the treatment can be used to prevent the stenosis of the bile duct (27).

Another experimental study, performed on dogs, used thin-walled FEP-ringed Gore-Tex vascular grafts, found to be useful in the repair of IBDLs, especially in complete transections of the CBD. The ductility and flexibility of the material allows any type of anastomosis to be performed, especially when bile duct-gut anastomosis is technically difficult (28).

To avoid bypass synthetic grafts which are expensive used in the treatment of IBDI after LC, there was evaluated by a Mexican medical team, the autologous implantation of peritoneum as alternative of bile duct repair. The experiment was made on 10 New Zealand adult rabbits, under general anesthesia, whose common bile duct was approached and sectioned underneath the cystic duct followed by a liver biopsy. An autologous graft was built of peritoneum and graft-bile duct proximal and distal end-to-end anastomosis done. Animals were followed-up and afterwards euthanized and a liver biopsy was done for histological examinations. The autologous graft was easy to create and all the rabbits survived the procedure. They did not develop jaundice or alterations in their normal habits. At necropsy, autologous grafts were removed and no signs of occlusion were noticed. Moderate short-term liver damage was observed but long-term damage was negligible. Bileoma and pyogenic liver abscess were observed in two animals. The results favorably match well-known procedures used for bile duct repair, especially in cases of severe injury (Bismuth-Strasberg E1-3): it seems less complicated than biliary diges-

tive bypass, not as expensive as synthetic grafts and much easier to build than human amnion graft. There can be concluded that interposing an autologous graft of peritoneum is an easy-to-create surgical procedure and circumferential bile duct injuries are adequately repaired (29).

CONCLUSIONS

The IBDLs are common, especially after laparoscopic cholecystectomy compared to open surgery. These continue to occur despite the increasing experience with the laparoscopic cholecystectomy procedure. The surgical experience of the MDs, the professional surgical technique, early recognition, and appropriate treatment and applied procedures should decrease the frequency and minimize the morbidity rates associated with these type of injuries.

The best treatment for the IBDLs is prevention by proper training of the young surgeons in the performance of a safe technique of cholecystectomy. The surgical care must also be exercised during other abdominal surgeries, complex gastrostomies, pancreatic operations, endoscopic biliary tract investigations and surgeries in order to preserve the bile ducts. The knowledge of the variants of biliary duct anatomy is crucial for every surgeon. Several studies indicate the routine use of intra-operative cholangiography in association with careful dissection of the blood supply in order to avoid any unexpected bleeding. It is also highly recommended that injuries recognized during the operation be repaired immediately using the specific technique suited to that very injury. On the other hand, injuries recognized in the early postoperative period do not require immediate repair except in the case of bile peritonitis.

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