Iatrogenic bile duct injury with loss of confluence

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AIM: To describe our experience concerning the surgical treatment of Strasberg E-4 (Bismuth IV) bile duct injuries.

METHODS: In an 18-year period, among 603 patients referred to our hospital for surgical treatment of complex bile duct injuries, 53 presented involvement of the hilar confluence classified as Strasberg E4 injuries. Imagenological studies, mainly magnetic resonance imaging showed a loss of confluence. The files of these patients were analyzed and general data were recorded, including type of operation and postoperative outcome with emphasis on postoperative cholangitis, liver function test and quality of life. The mean time of follow-up was of 55.9 ± 52.9 mo (median = 38.5, minimum = 2, maximum = 181.2). All other patients with Strasberg A, B, C, D, E1, E2, E3, or E5 biliary injuries were excluded from this study.

RESULTS: Patients were divided in three groups: G1 \( (n = 21) \): Construction of neoconfluence + Roux-en-Y hepatojejunostomy. G2 \( (n = 26) \): Roux-en-Y porto-enterostomy. G3 \( (n = 6) \): Double (right and left) Roux-en-Y hepatojejunostomy. Cholangitis was recorded in two patients in group 1, in 14 patients in group 2, and in one patient in group 3. All other patients with Strasberg A, B, C, D, E1, E2, E3, or E5 biliary injuries were excluded from this study.

CONCLUSION: Loss of confluence represents a surgical challenge requiring careful planning and meticulous execution.
challenge. There are several treatment options at different stages. Roux-en-Y bilioenteric anastomosis (neoconfluence, double-barrel anastomosis, porto-enterostomy) is the treatment of choice, and when it is technically possible, building of a neoconfluence has better outcomes. When liver cirrhosis is shown, liver transplantation is the best choice.

Key words: Bile duct injury; Hepatojejunostomy; Biliary repair; Portoenterostomy; Neoconfluence; Double-barrel anastomosis

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Core tip: Strasberg E-4 (Bismuth IV) bile duct injuries represent a surgical challenge. These injuries which involve two separated right and left ducts are of multifactorial etiology, and may be the result of ischemic or thermal damage, an inflammatory reaction, or anatomical variants that predispose the patient to injury. The treatment options are many, mainly surgical. Best results are obtained with Roux-en-Y hepatojénostomies, as we describe in this article.

INTRODUCTION

Bile duct injuries following laparoscopic approach have been extensively studied. Several classifications have been developed to describe both the mechanism by which the injury occurs and the anatomic result. Classification of these injuries is challenging, although possible, since each lesion is not only anatomically unique, but also the final result of several factors, such as duct ischemia, thermal injury and ablation, and transection of the duct. These injuries have been found to have a constant rate, regardless of the surgeon’s experience or the hospital (0.3%-0.6%).

One of the most feared types of injury is that which involves the confluence. They are classified as Bismuth IV and Strasberg E4 injuries, and represent a surgical and multidisciplinary challenge (Figure 1). Loss of the confluence, in which one or two right ducts are separated from the left duct, represent a technical challenge with several therapeutic options. These include various types of bilioenteric anastomosis as well as major hepatectomy. Here we describe our experience with this type of injury and the results of our surgical treatment, which in most instances, is the only option available to treat this type of injuries.

MATERIALS AND METHODS

During an 18-year period we studied 603 patient candidates for surgical treatment of iatrogenic bile duct injury. The conditions in which these patients arrived at our center are highly variable; each patient has an individual history and timeline. Several have received previous endoscopical, radiological, or surgical therapy.

Patients were evaluated by a multidisciplinary group that selects patients with ductal continuity for endoscopical and/or radiological treatment. Those with loss of continuity are selected for surgical management. Patient selection and injury classification are carried out based on results of several imaging studies, including magnetic resonance cholangiography, computerized tomography, and ultrasound. Endoscopic retrograde cholangiography is selectively performed on patients in whom there is a suspicion of a lateral injury that can be resolved with a stent. Patients who arrive with acute cholangitis, or in whom injury classification cannot be determined, are studied by percutaneous cholangiography. Surgery is programmed according to the general condition of the patient. When patients present multiple organ failure and/or evident sepsis, the procedure is delayed as long as needed. Until the general condition of the patient improves, percutaneous or surgical placement of a drain is the treatment of choice. Injuries are classified according to the Strasberg and Bismuth classifications.

All cases in which there is loss of duct continuity and thickness, duct transection is treated surgically by means of a Roux-en-Y hepatojénostomy. The type and characteristics of the anastomosis have been described previously[1,2].

Medical records of all patients in whom loss of confluence was found (injuries classified as Bismuth IV, Strasberg E4) were analyzed and their general data were recorded. Type of surgical procedure, postoperative outcome with emphasis on postoperative cholangitis, liver function tests, and quality of life were also recorded. The mean time of follow-up of these patients was of 55.9 ± 52.9 mo (median = 38.5, minimum = 2, maximum = 181.2). For analysis purposes, patients were divided into three groups according to type of surgical repair. These groups and their characteristics are described on Table 1.

RESULTS

Among the 603 cases of biliary duct injuries, 53 cases with loss of confluence were identified. Most of the cases had a preoperative external biliary fistula (n = 27) with different types of abdominal or percutaneous drains. There was a wide range of time between the index surgery (where the injury was produced) and the attempts to repair in our institution (mean 14 d). In 28 cases the diagnosis of loss of confluence was
the intestinal mucosa (Figure 2B).

The 9 cases in which stents were placed have had an adequate postoperative evolution without symptoms and cholangitis. Stents were removed between the 6th and the 9th postoperative months. In two cases they were left in place longer, one for 12 mo due to patient non-compliance, and one for 84 mo due to patient's request. After this, the patients were left without a stent. In the other 7 patients whose stent was removed, 4 remained asymptomatic, 1 patient died in the fourth postoperative year because of secondary biliary cirrhosis, 1 patient in whom cirrhosis and liver failure were recorded was lost to follow-up, and 1 has developed cirrhosis and jaundice.

**Group 3: Loss of confluence and double-barrel anastomosis**

In 6 cases, both ducts were identified, but construction of a neo-confluence was not possible. Therefore, a

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**Table 1 Patient groups according to surgical procedure followed**

| Group | Surgical procedure to repair loss of confluence | n (%) |
|-------|-----------------------------------------------|------|
| G1    | Construction of neo-confluence + Roux-en-Y hepatojejunostomy | 21 (40%) |
| G2    | Roux-en-Y Portoenterostomy                      | 26 (49%) |
| G3    | Separated (right and left) Roux-en-Y hepatojejunostomy | 6 (11%) |

**Figure 1** Strasberg E-4 injury.

**Figure 2** Hepatojejunostomy. A: Neoconfluence; B: Portoenterostomy; C: Double-barrel.
A double-barrel anastomosis was performed. Three of these patients remained asymptomatic in the postoperative period (mean 6 years, range 3-12). Two cases required a right hepatectomy several months after the reconstruction because of persistent sectionary (unilobar) cholangitis. They are currently doing well, with patent bilioenteric anastomosis. One patient had persistent cholangitis and developed cirrhosis in the 4th postoperative year after one reoperation and attempts to perform radiological percutaneous dilation and surgical and radiological placement of stents (Figure 2C).

Figure 3 shows a summary of the surgical treatment strategy followed for bile duct injuries with loss of confluence.

Results after first reconstruction
The frequency of perioperative complications in patients treated by means of a Roux-en-Y portoenterostomy (group 2) was of 57.6%. The postoperative complications of these patients according to the Clavien-Dindo grading system are shown in Table 2.

Sixteen (61.5%) group 2 patients presented cirrhosis during follow-up, while 10 (38.4%) haven’t developed cirrhosis to the last moment of follow-up. Thirteen patients (50%) have been referred for hepatic transplant evaluation, and 3 (11.5%) haven’t been sent because of compensated cirrhosis.

On the other hand, 14 (53.8%) group 2 patients developed cholangitis. The cholangitis free survival rate was of $45 \pm 9.17$ mo (95%CI: 27.1-63) as shown in Figure 4.

Of these patients, 4 out of 9 patients in which a T-tube was placed (44.5%) required percutaneous interventions after their removal. Two patients (22.2%) needed the placement of an internal-external biliary drainage catheter after removal of the T-tube, while in the other 2 patients (22.2%) the T-tube was replaced with a percutaneous biliary catheter which wasn’t removed until 11.1 mo after.

Four patients out of the 17 in which a T-tube wasn’t placed (65.3%) required the placement of an internal-external biliary drainage. Only one of them (25%) is free of drainages at 63.7 mo.

Seven (77.8%) group 2 patients in which a T-tube was placed developed cholangitis during follow-up.
Table 2  Group 2 postoperative complications according to the Clavien-Dindo grading system

| Classification | Frequency (%) | Description (frequency) |
|----------------|---------------|-------------------------|
| I              | 1 (3.8%)      | Superficial surgical site infection (1) |
| II             | 7 (26.9%)     | Intra-abdominal collection not requiring surgical intervention (5) | Intra-abdominal collection requiring surgical intervention (1) |
| IIIa           | 0 (0%)        | Intra-abdominal collection requiring surgical intervention (1) |
| IIIb           | 3 (11.5%)     | Biliary anastomosis remodeling (1) | Intra-abdominal collection requiring transendoscopic ultrasound drainage (1) |
| IVa            | 3 (11.5%)     | Septic shock (3) |
| IVb            | 0 (0%)        | Atrioventricular block (1) |
| V              | 1 (3.8%)      | Atrioventricular block (1) |

Those in which a T-tube wasn’t placed, 7 (41.2%) presented this complication. Nonetheless, there was no significant difference between these two subgroups \( (P = 0.075) \). Cholangitis free survival rate tended to be greater in those patients without placement of a T-tube \( (60.1 \pm 11.6 \text{ mo}, 95\% \text{CI}: 37.4-82.9; \text{ vs } 23.1 \pm 8.6, 95\% \text{CI}: 6.2-40; \text{ log-rank } P = 0.056) \) (Figure 5).

**DISCUSSION**

Surgical treatment of bile duct injury is indicated when loss of duct continuity is found and endoscopic and/or radiological approach is ruled out\(^3\). Roux-en-Y hepatojejunostomy has been proven to be the best treatment option by several groups\(^3\). A high quality bilioenteric anastomosis, which is defined as tension-free, wide, with adequate suture material, done in healthy, non-scarred non-ischemic ducts that are anastomosed to an afferent Roux-en-Y jejunal limb, offers the best results\(^4\). There are several technical maneuvers that can be done in order to reach this goal, including the anterior opening of the confluence and the left duct, as well as partial removal of segments IV and V\(^5,6\).

Our group has shown that an anastomosis done in a patient with preserved confluence offers the best results\(^7\). These results can be also optimized if the patient has no stones or sludge, usually the result of secondary colonization of bile.

Loss of confluence, depicted in Bismuth classification as IV and in Strasberg classification as E-4, is one of the most feared scenarios for surgeons, because of the technical challenge that it represents.

Loss of confluence can be the result of several issues. In some instances, it is the result of an anatomical variation in which the given patient has a low extrahepatic confluence that is injured during dissection, and also in subsequent section, transection or occlusion of the duct can be performed at this level. There is no available data on how many individuals have a low extrahepatic confluence. In the majority of people the confluence, although extrahepatic, is not low. In these cases, loss of confluence is the result of ischemic damage, thermal damage or both.

After section of the common duct, the proximal stump (near to the plane of section) becomes ischemic. It has been stated by Strasberg \( et\ al\)\(^5\) that one of the key features for successful repair and successful bilio-enteric anastomosis is to wait enough time, so that the injury stabilizes and the exact level of duct ischemia is reached\(^8\). So, in some cases the ischemia level reaches the confluence. Bismuth has also stated that the level of the injury is always higher than it is appreciated in the initial stump\(^9\).

In other cases, loss of confluence is the consequence of the local inflammatory reaction produced by either bile leakage or drains placed for a long time in the common duct, which lead to consequent destruction. This is especially true when patients in whom a non-silastic drain is placed subhepatically and fixed to the bile duct, establishing an external fistula, are referred late. Right hepatic arterial injuries are usually seen in this type of injury. Stewart \( et\ al\)\(^10\) have shown that...
because of the danger of devascularization. When very important not to manipulate the ducts excessively level, both ducts are identified at the hilar plate. It is after removal of the liver parenchyma at the hilar place them was made according to the characteristics of a given patient.

In conclusion, an injury that includes the loss of confluence of the duct represents a surgical challenge. There are several options to be considered (neoconfluence, double-barrel anastomosis and portoenterostomy) that must be shaped and selected according to the individual characteristics of a given patient.

**COMMENTS**

**Background**

One of the most complex bile duct injuries is that which involves the loss of confluence of the right and left bile ducts, namely a Strasberg E-4 injury. Initially, the authors’ team’s surgical approach to this problem was the forming of a double-barrel anastomosis; however, it resulted in long term dysfunction. By descending the hilar plate, performing a partial resection of segment IV, and liberating both bile ducts so as to approximate them and include them in the liver capsule and/or parenchyma.

The decision to place a transanastomotic stent is always difficult. When our group first started, we decided to place stents in all cases, but we evolved to selective placing when needed specifically when ducts were deemed small and not of good quality. As we have stated, each patient has an individual type of injury and resulting anatomy.

Overall, considering all the treatments modalities, the procedure was successful in 88% of the cases, obtaining good postoperative results without cholangitis, good quality of life and without requiring reintervention. In conclusion, an injury that includes the loss of confluence of the duct represents a surgical challenge. There are several options to be considered (neoconfluence, double-barrel anastomosis and portoenterostomy) that must be shaped and selected according to the individual characteristics of a given patient.

**Research frontiers**

Many surgical treatments for loss of confluence bile duct injuries have been proposed, including the creation of a two-barrel anastomosis, a portoenterostomy, or a neoconfluence. Few have described results regarding any of these reconstructions.

**Innovations and breakthroughs**

To our knowledge, this is the first retrospective study that analyzes long term outcomes of neoconfluences in iatrogenic bile duct injuries. They have only
The manuscript is interesting and well written.

**Applications**
Roux-en-Y hepatojejunostomies offer the best outcomes in patients with bile duct injuries with loss of confluence, as reported in the authors’ observations. Individual characteristics of the patient must be taken into account in order to decide the most suitable surgical approach, although creating a neoconfluence should be of top priority.

**Terminology**
Bile duct injuries represent all deleterious consequences on the intra- or extrahepatic bile ducts, as a result of the removal of the gallbladder or of any endoscopic and surgical instrumentation of the ducts. Cholangitis is one of the most important complications that arise from these injuries, usually due to inflammation and fibrosis caused by biliary leaks.

**Peer-review**
The manuscript is interesting and well written.

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