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Management of Bile Duct Injury Reconstruction Using The *Ri-Kunaro Technique* : A Case Series

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ABSTRACT

Bile duct injury (BDI) following cholecystectomy is uncommon but can result in substantial morbidity, repeated interventions, prolonged hospitalization, and increased healthcare costs. Reported incidence ranges from 0.2% to 0.5%, and mortality has been reported in up to 7% of affected patients. Reconstruction is intended to restore dependable bile flow to the gastrointestinal tract. This case series describes the use of the *Ri-Kunaro* reconstruction technique for post-cholecystectomy bile duct injury.
We reviewed three patients treated at our center between May and September 2025 for bile duct injury following laparoscopic or open cholecystectomy. Each patient underwent biliary reconstruction using the *Ri-Kunaro* technique, a modified Roux-en-Y hepaticojejunostomy incorporating two trans-anastomotic biliary stents and postoperative endoscopic sphincterotomy.
All three patients underwent exploratory laparotomy, drainage of the biloma when present, adhesiolysis, and biliary reconstruction with double stent placement. Postoperative bile drainage improved in each case. These preliminary observations suggest that the *Ri-Kunaro* technique is technically feasible; however, larger cohorts and longer follow-up are needed to establish its safety and durability.

INTRODUCTION

Bile duct injury (BDI) is an infrequent but serious complication of cholecystectomy. Its reported incidence is approximately 0.2-0.5%[1]. Because cholecystectomy is performed so frequently, even this low rate produces a meaningful clinical burden. Affected patients may experience persistent physical and psychological morbidity, repeated interventions, and prolonged hospitalization; mortality rates of up to 7% have also been reported[2]. Definitive surgery seeks to re-establish unobstructed bile drainage into the gastrointestinal tract. The reconstructive approach must be tailored to the injury pattern, local anatomy, tissue viability, and available hepatopancreatobiliary expertise[3].

METHODS

This case series included three patients managed at our center from May through September 2025 for BDI after laparoscopic or open cholecystectomy. All underwent biliary reconstruction with the *Ri-Kunaro* technique. This modification of Roux-en-Y hepaticojejunostomy combines standard bilioenteric reconstruction with two trans-anastomotic biliary stents and routine postoperative endoscopic sphincterotomy.

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RESULTS

The first patient was an 18-year-old woman with an iatrogenic Strasberg E2 BDI, biloma, and grade III-IV intestinal adhesions following a laparoscopic cholecystectomy that was converted to an open operation for multiple gallstones at Ciereng Subang Regional Hospital on May 26, 2025. Three weeks after the index operation, approximately 1,900 mL of bile was collected from the abdominal drain one week after ERCP with sphincterotomy. Drain output ceased within two months, and the biliary stent was left in situ.

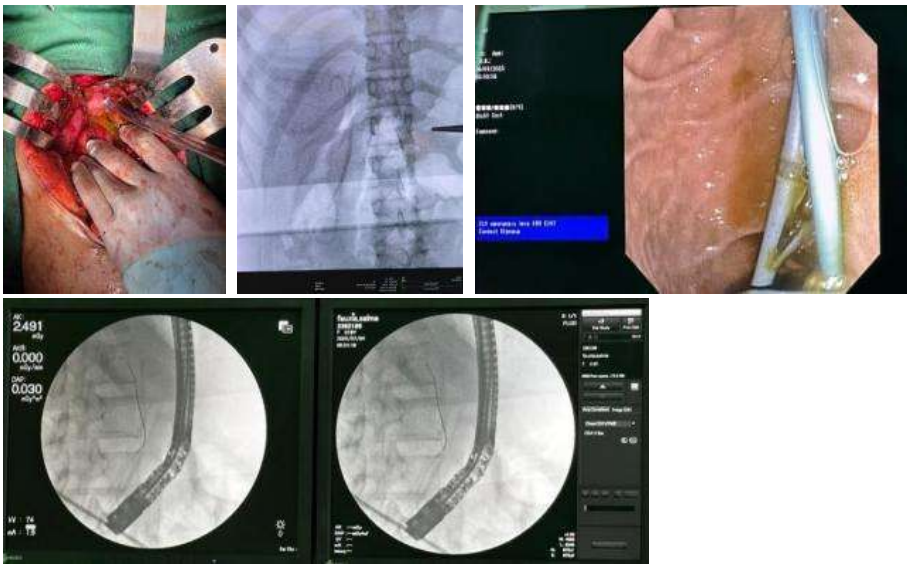

Figure 1. Intraoperative finding and intraoperative cholangiography

The second patient was a 27-year-old woman with an iatrogenic Strasberg E4 BDI and biloma after laparoscopic cholecystectomy at Mitra Kasih Hospital on August 29, 2025. Abdominal drain output remained below 50 mL per day for seven days. ERCP with sphincterotomy demonstrated free drainage of bile into the duodenum, and the biliary stent was retained.

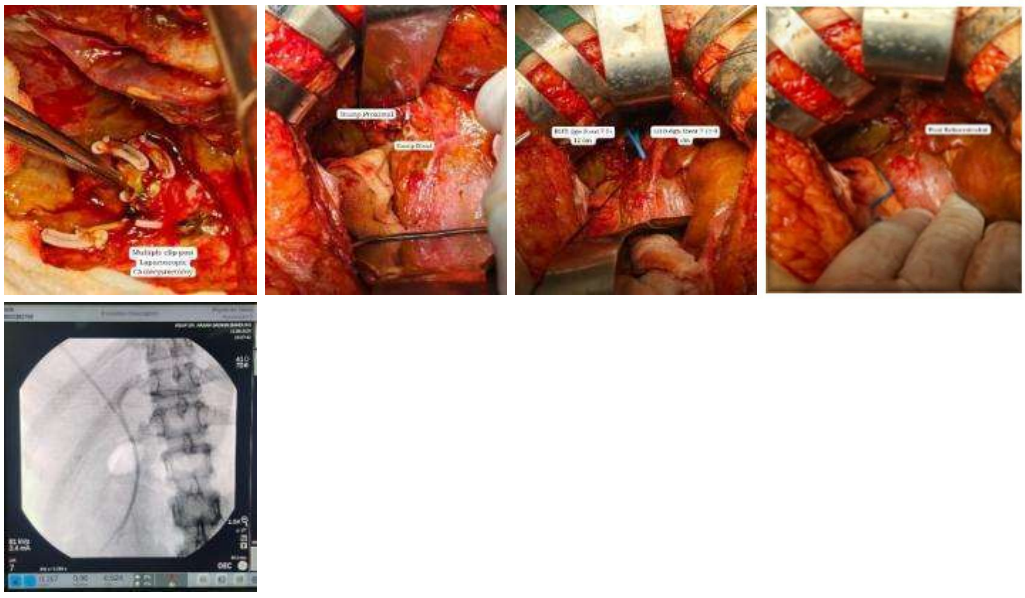

Figure 2. Intraoperative finding and intraoperative cholangiography

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The third patient was a 29-year-old woman with common hepatic duct stenosis following laparoscopic cholecystectomy converted to an open procedure in January 2024 at Garut Regional Hospital. She had previously undergone ERCP at RSHS in August 2025. Abdominal drain output was less than 50 mL per day for seven days. After ERCP with sphincterotomy, bile flowed freely into the duodenum; the biliary stent remained in place.

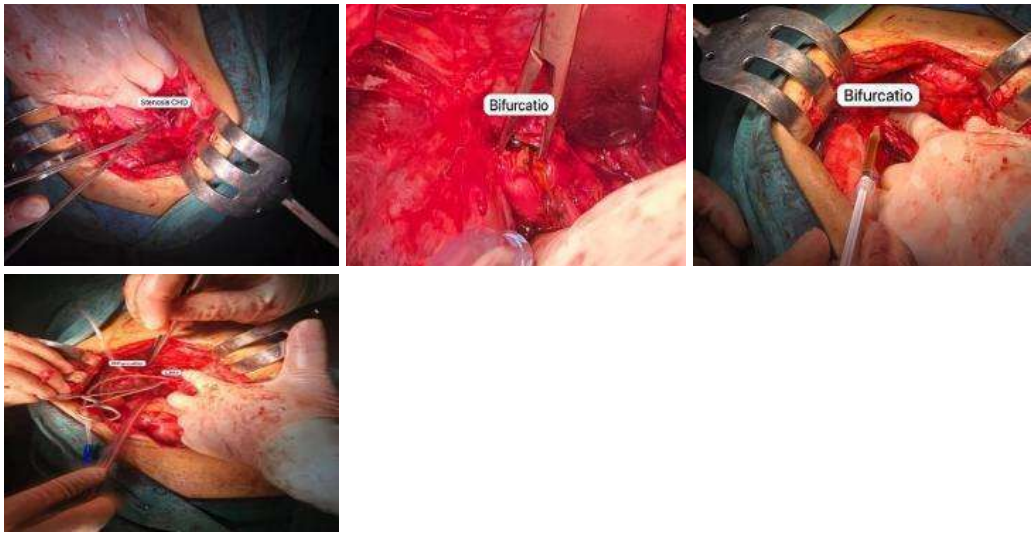

Figure 3. Intraoperative finding and intraoperative cholangiography

DISCUSSION

Nomenclature

Terminology for BDI and its sequelae remains inconsistent: different labels may be applied to the same event, while a single term may denote distinct clinical conditions. A standardized vocabulary developed from experience with BDI and benign biliary stricture distinguishes the timing, anatomic extent, and consequences of injury. Relevant terms include acute BDI, bile leak, biloperitoneum, biloma, bile peritonitis, bile ascites, minor or major injury, partial or complete injury, high or complex injury, and biliary drainage[4].

Classification of Bile Duct Injury

No single classification captures every clinically relevant feature of BDI. Existing systems variously emphasize the level of injury relative to the hepatic confluence, ductal continuity, associated vascular damage, tissue loss, timing of recognition, and mechanism[5]. The principal systems are summarized below.

Bismuth-Corlette classification (1982): This system locates an injury in relation to the hepatic hilum and biliary confluence. It considers involvement of the bifurcation and right sectoral duct, while the length of viable proximal duct helps determine the reconstructive options[5] (Figure 4).

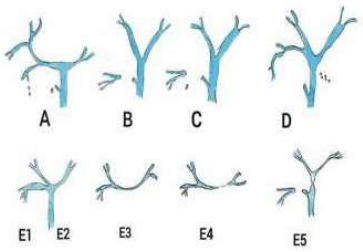

Figure 4. Bismuth's classification of bile duct injuries.

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Strasberg-Bismuth classification (1995): Strasberg expanded the Bismuth framework to include patterns commonly encountered after laparoscopic cholecystectomy. Types A-D describe leaks, aberrant-duct occlusion or division, and lateral main-duct injury, whereas type E corresponds to the Bismuth levels. The system does not explicitly encode vascular injury and may not fully describe some isolated right- or left-duct lesions[5] (Figure 7).

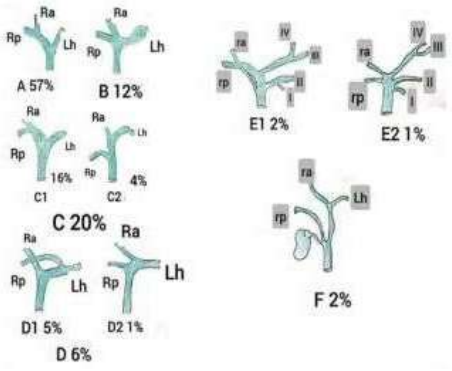

Figure 5. Anatomical abnormalities of right hepatic duct.

Lau/CUHK classification (2007): This scheme extends the Bismuth approach by incorporating vascular injury and arranging categories in increasing order of severity. Because each category reflects a distinct mechanism and anatomic pattern, it can also inform prevention and treatment planning[5].

Stewart-Way classification: Four classes combine mechanism with anatomy. Class I denotes an incomplete common bile duct injury caused by misidentification or extension of a cholangiotomy; class II is a lateral common hepatic duct injury; class III is complete transection or excision of the main duct, including the cystic duct-common hepatic duct junction; and class IV involves leakage or transection of the right hepatic or a right sectoral duct, sometimes with vascular injury[5].

EAES ATOM classification (2013): The ATOM system records three dimensions of BDI: the anatomic pattern, including vascular involvement; the time at which the injury is detected; and whether the mechanism is mechanical or energy-related. By combining variables used in earlier systems, ATOM provides a comprehensive description for reporting and comparison, although its level of detail may limit routine bedside use[4].

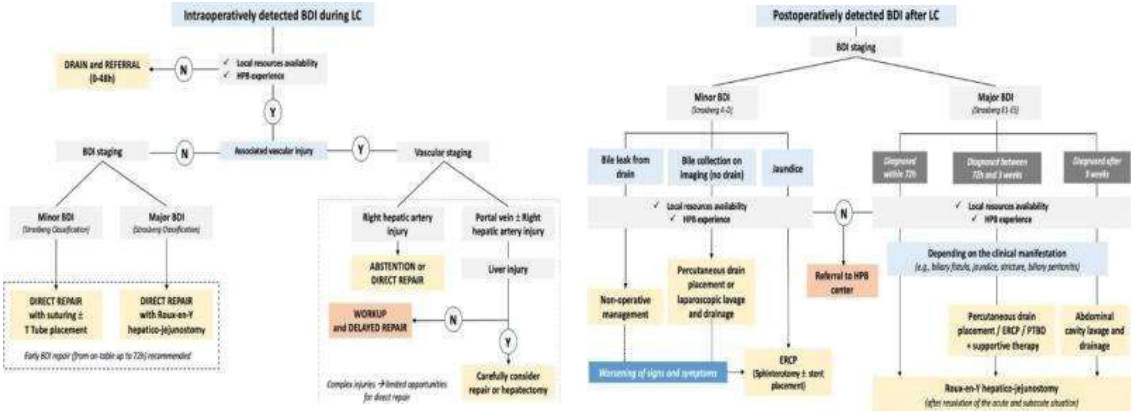

Figure 6. Diagram of Intraoperatively detected BDI during LC and Postoperatively detected BDI after LC

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Key features	
Bismuth	• Introduced in 1982 • Five levels defined by the location of injury relative to the hepatic confluence
Siewert	• Introduced in 1994 • Five categories describing leakage, obstruction, and vascular injury after open surgery
Strasberg	• Introduced in 1995 • Extends Bismuth to include injury patterns associated with laparoscopic cholecystectomy
McMahon	• Introduced in 1995 • Designed for laparoscopic injuries • Distinguishes minor and major injury according to the width of ductal damage
Amsterdam	• Introduced in 1996 • Four categories (A-D) based on leakage, obstruction, isolated stricture, or transection
Neuhaus	• Introduced in 2000 • Emphasizes patterns associated with later complications • Five groups (A-E) that include occlusion, stenosis, and tangential injury
Stewart-Way	• Derived from analyses of injury mechanisms • Four classes (I-IV) linking anatomic damage to common errors in operative recognition
Sandha	• Introduced in 2004 • Uses ERCP findings and an algorithmic approach to bile leakage, including associated stones
Lau	• Introduced in 2007 as a modification of the Mattox framework • Five categories (A-E) describe injury level, severity, vascular involvement, and tissue loss
Hannover	• Introduced in 2007 • Five groups (A-E) encompass ductal injury, bile leakage, and adjacent vascular damage
ATOM (Anatomy, Time of detection, Mechanism)	• Introduced in 2013 • Integrates anatomic extent, early or late recognition, and mechanical or energy-related injury

Table 1. Overview of bile duct injury classification systems[4,5].

Clinical Presentation

Prompt recognition is important because postoperative BDI often first appears as bile leakage or biliary obstruction. A leak may produce nonspecific abdominal pain, nausea, fever, distension, or loss of appetite. Obstruction or common bile duct stricture may present with right upper-quadrant pain,

fever, and jaundice. Intra-abdominal abscess, recurrent cholangitis, biliary stricture, and secondary biliary cirrhosis may develop during short- or long-term follow-up[7].

Risk Factors

The likelihood of BDI reflects an interaction among patient characteristics, variant biliary anatomy, local inflammation, and operative technique.

1. **Patient-related factors:** Conditions associated with a more difficult dissection include obesity, underlying liver disease, and previous hepatobiliary or pancreatic surgery[8].
2. **Anatomic factors:** Misinterpretation of biliary anatomy is a major mechanism of injury during laparoscopic cholecystectomy. A short cystic duct, a cystic duct that runs parallel to the common bile duct, hepatocystic or accessory ducts, and aberrant bile ducts can obscure the expected landmarks. An aberrant right hepatic duct is particularly important, and excessive or poorly directed gallbladder traction may further distort the anatomy[9] (Figure 5).

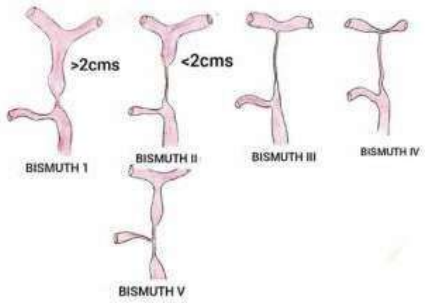

Figure 7. Strasberg-Bismuth classifications.

3. Technical factors

Technical risk is greatest when operative experience is limited or the dissection is made difficult by acute inflammation and distorted tissue planes. Emergency surgery, insecure cystic-duct closure, deep dissection in the liver bed, and uncontrolled use of thermal energy or clips can all contribute to ductal injury[8,9].

Preventive Measures for Iatrogenic BDI

Prevention begins with deliberate identification of the cystic duct, cystic artery, and nearby vascular structures before division. Intraoperative cholangiography, the infundibular approach, and the critical view of safety may assist when the anatomy is uncertain. Hunter and Troidl recommended a 30-degree laparoscope, avoidance of thermal energy near the common hepatic duct, limited dissection around the gallbladder-cystic duct and cystic-common hepatic duct junctions, and conversion to an open operation when safe identification cannot be achieved[10,11]. Sari et al. described gallbladder injection of methylene blue after bile aspiration as an additional aid[12]. Gentle traction and avoidance of blind diathermy or clip application remain essential.

Management of Bile Duct Injury

Management has three objectives: control bile leakage and sepsis, preserve viable ductal and vascular tissue, and restore durable biliary drainage. The plan should be individualized according to injury anatomy, clinical stability, associated vascular damage, timing of recognition, and access to hepatopancreatobiliary expertise. The Strasberg system provides a practical anatomic framework for this decision[6,15].

Strasberg types A-D do not constitute a single therapeutic group. Type A leaks usually retain continuity with the biliary tree and can often be treated by endoscopic decompression, with or without stent placement. Type B injuries represent occlusion of an aberrant duct and may require drainage or limited surgery if cholangitis develops. In type C injury, the divided aberrant duct does not communicate with the remaining biliary system; associated collections must be drained and further treatment selected according to the volume and persistence of leakage. Type D is a lateral injury of a major duct. A small,

well-perfused defect may be repaired primarily, whereas a larger or ischemic defect warrants multidisciplinary drainage and, when necessary, definitive reconstruction[5,6,15].

Strasberg E1-E5 injuries involve transection or stricture of the major bile ducts and may be accompanied by tissue loss or ischemia. These lesions generally require bilioenteric reconstruction at a specialist center, most often a Roux-en-Y hepaticojejunostomy constructed using healthy, well-vascularized duct tissue[6,15].

Associated vascular injury can substantially alter the operative strategy. When no vascular compromise is present, early definitive reconstruction may be appropriate if an experienced hepatopancreatobiliary surgeon is available. Suspected right hepatic artery injury requires assessment of arterial flow and parenchymal viability before repair is attempted. Combined portal, arterial, and hepatic parenchymal injury may necessitate delayed reconstruction, vascular intervention, or liver resection[6].

Timing is guided by both presentation and expertise. A major BDI recognized within 72 hours should prompt referral to an HPB center, where urgent Roux-en-Y hepaticojejunostomy may be considered. When diagnosis occurs between 72 hours and 3 weeks, initial care should focus on drainage of collections, targeted antibiotics, nutritional support, and selected use of ERCP or PTBD. Reconstruction is then performed after the acute inflammatory process has resolved and the patient has been optimized. Diffuse biliary peritonitis requires urgent lavage and drainage for source control[6].

At our institution, the three patients with complex BDI underwent the *Ri-Kunaro* reconstruction, a modification of Roux-en-Y hepaticojejunostomy. The operation uses two trans-anastomotic biliary stents, followed by postoperative endoscopic sphincterotomy, to facilitate bile drainage while the bilioenteric anastomosis heals.

When BDI is recognized after the index operation, imaging should define both the injury and any associated collection before reconstruction. Ultrasonography and contrast-enhanced CT identify biloma or intra-abdominal sepsis and can guide percutaneous drainage. MRCP provides noninvasive mapping of the biliary tree, whereas hepatobiliary scintigraphy may demonstrate active leakage. ERCP and percutaneous transhepatic cholangiography can combine diagnosis with treatment. ERCP is most useful when ductal continuity permits transpapillary decompression or stenting; percutaneous access can provide controlled external drainage when the duct is completely transected[13-15].

Follow Up

Immediate postoperative period: Monitor vital signs, abdominal findings, drain volume and character, bilirubin, and liver biochemical tests. New fever, pain, jaundice, or increasing bile output should prompt evaluation for leakage, obstruction, or intra-abdominal infection.

Short-term follow-up (1-3 months):

Imaging: Use ultrasonography, CT, or MR imaging when clinically indicated to evaluate the anastomosis and detect residual collection, leakage, or early stricture.

- **Laboratory monitoring:** Serial liver biochemical tests help identify persistent obstruction or hepatocellular injury.
- **Clinical review:** Assess abdominal pain, fever, jaundice, pruritus, appetite, and other features of infection or impaired bile drainage.

Long-term follow-up (>6 months):

- **Imaging and liver tests:** Periodic assessment may identify late anastomotic stricture, recurrent obstruction, or secondary liver injury.
- **Symptom surveillance:** Recurrent pain, fever, jaundice, or cholangitis should trigger prompt reassessment.
- **ERCP:** Repeat endoscopy may be appropriate for selected patients who require evaluation or treatment of a postoperative biliary stricture.

Management of complications: Depending on anatomy and severity, a stricture may require balloon dilatation, stent therapy, percutaneous intervention, or surgical revision.

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Patient education: Explain warning symptoms, the importance of scheduled follow-up, and the need for ongoing monitoring of liver function[6,13,15].

CONCLUSION

In this three-patient case series, exploratory laparotomy, biloma drainage when required, adhesiolysis, and *Ri-Kunaro* biliary reconstruction with two trans-anastomotic stents were technically feasible. All patients also underwent postoperative ERCP with sphincterotomy, and their early clinical courses were favorable. The technique may represent an alternative for selected complex BDIs, but its safety and long-term durability require evaluation in larger cohorts with standardized follow-up.

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