CBD injury

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Introduction

- Bile duct injury (BDI) represents the most serious complication of LC
- Incidence of 0.3%–0.7%
  - Increase of incidence since LC become gold standard of treatment
- Resulting in a significant impact on QoL, overall survival, and frequent medico-legal liabilities
- Primary cause : Misinterpretation of biliary anatomy in 71%–97% of all cases

BOX 42.2 Classification of Causes of Laparoscopic Biliary Injuries

- Misidentification of the bile ducts as the cystic duct
- Misidentification of the common bile duct as the cystic duct
- Misidentification of an aberrant right sectoral hepatic duct as the cystic duct
- Technical causes
- Improper techniques of ductal exploration
- Failure to occlude the cystic duct securely
- Plane of dissection away from gallbladder wall into the liver bed
- Excessive traction on cystic duct with tenting upward of common hepatic duct
- Injudicious use of electrocautery for dissection or bleeding control
- Injudicious use of clips to control bleeding

Modified from Strasberg SM, Hertl M, Soper NJ. An analysis of the problem of biliary injury during laparoscopic cholecystectomy. *J Am Coll Surg.* 1995;180:101–125.

Pesce et al. Iatrogenic bile duct injury: impact and management challenges. Clinical and Experimental Gastroenterology 2019:12 121–128
BLUMGART'S Surgery *of the* Liver, Biliary Tract and Pancreas. 7th ed. 2023

Classification

- Bismuth-Corlette classification
  - Information on the nature, risks, and prognosis after the repair
  - Correlation between the types of injury and the morbidity, mortality, success, and recurrence rates after repair
  - Correlates with the cholangiographic appearances
  - Disadvantage
    - Difficult to apply to LC
      - Classification was introduced before the era of LC
    - Not include the length of BDI and has not included associated vascular injuries

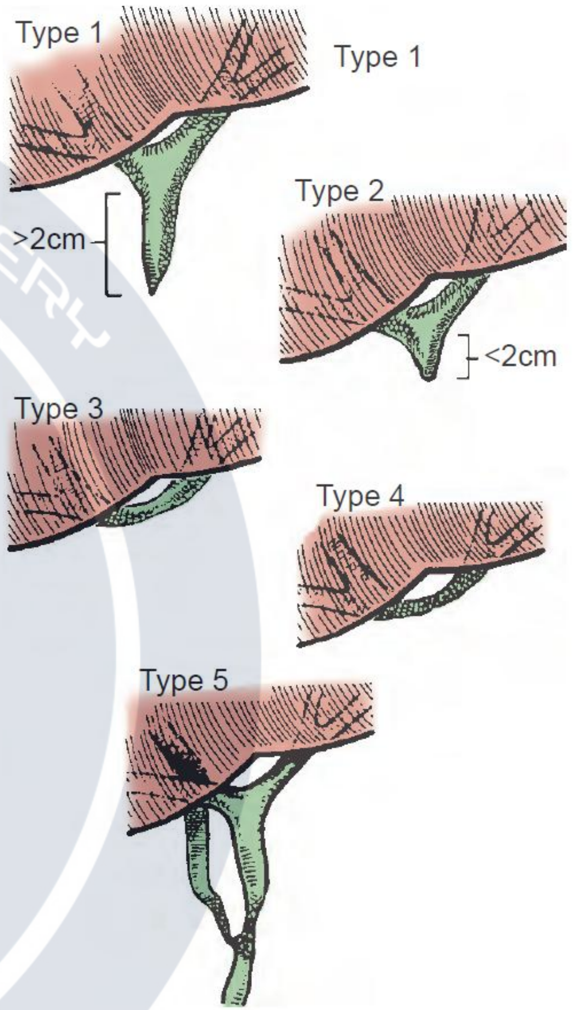

FIGURE 42.20 Classification of bile duct strictures based on location with respect to the hepatic duct confluence (see Table 42.1). (From Bismuth H: Postoperative strictures of the bile duct. In Blumgart LH [ed]: *The biliary tract: Clinical surgery international.* Edinburgh, 1982, Churchill Livingstone, pp 209–218.)

Nasa et al. Bile Duct Injury- Classification and Prevention.J Digest Endosc 2020;11:182–186
BLUMGART'S Surgery *of the* Liver, Biliary Tract and Pancreas. 7th ed. 2023

Classification

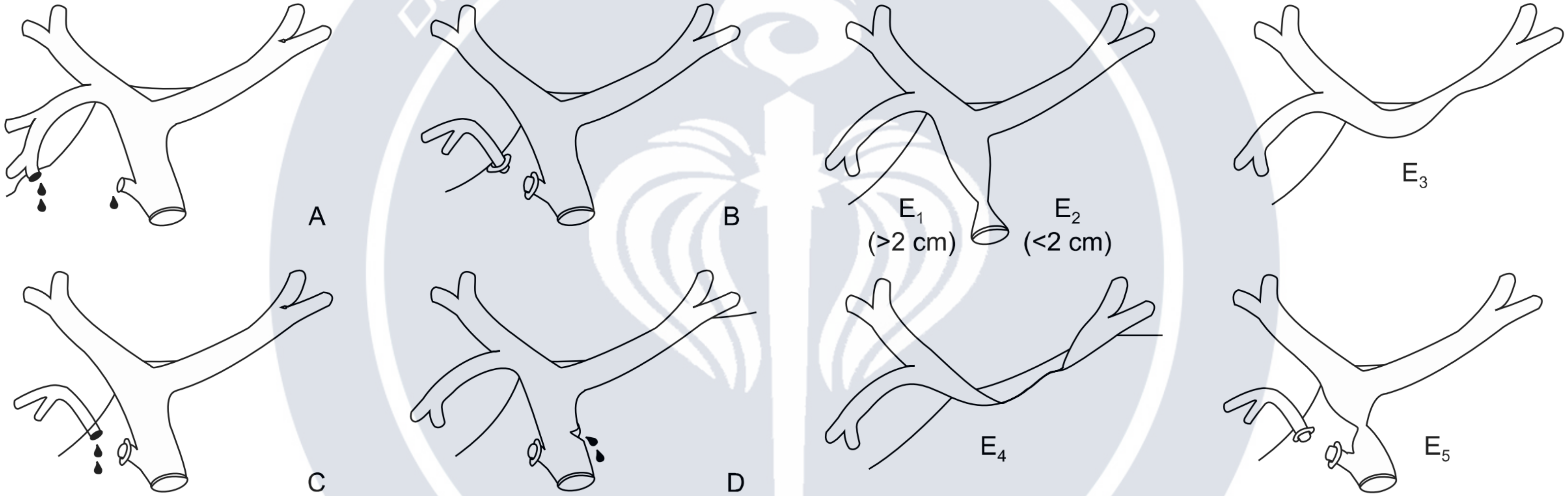

Fig. 1. Strasberg classification.[3,22] (A) Bile leak from cystic duct stump or minor biliary radical in gallbladder fossa. (B) Occluded right posterior sectoral duct. (C) Bile leak from divided right posterior sectoral duct. (D) Bile leak from main bile duct without major tissue loss. (E_1) Transected main bile duct with a stricture more than 2 cm from the hilus. (E_2) Transected main bile duct with a stricture less than 2 cm from the hilus. (E_3) Stricture of the hilus with right and left ducts in communication. (E_4) Stricture of the hilus with separation of right and left ducts. (E_5) Stricture of the main bile duct and the right posterior sectoral duct.

Kwangsik Chun. Classifications of bile duct injury. Korean J Hepatobiliary Pancreat Surg Vol. 18, No. 3, August 2014

Classification

- Stewart-Way classification
  - Based on the mechanism and anatomy of bile duct injuries and also includes concomitant vascular injuries
    I. CBD is mistaken for cystic duct/cystic duct incision for intraoperative cholangiogram extends to CBD
    II. Lateral injury to common hepatic duct
    III. Complete transection of main bile duct, this is the most common injury and includes cystic duct-common hepatic duct junction as well
    IV. Leak/transection of right hepatic duct/posterolateral sectoral duct

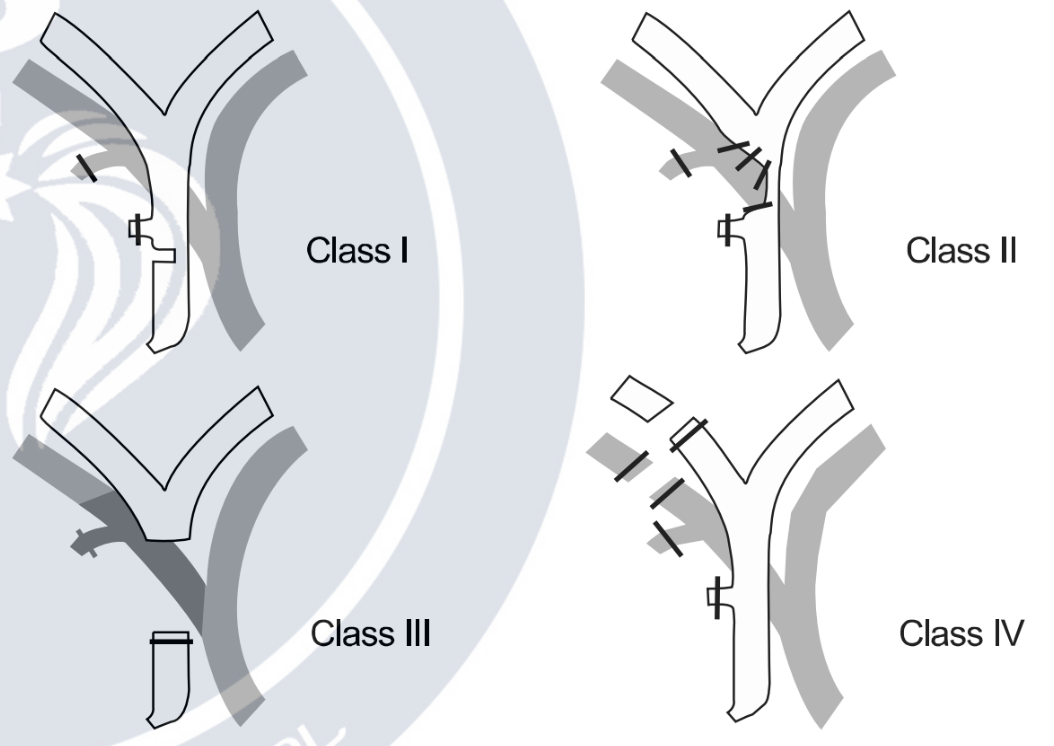

Fig. 2. Stewart-Way classification.[15]

Kwangsik Chun. Classifications of bile duct injury. Korean J Hepatobiliary Pancreat Surg Vol. 18, No. 3, August 2014

Classification

- ATOM classification
  - A : Anatomic characteristics of the injury
    - Main bile duct(MBD)
    - Non-main bile duct(NMBD)
    - Occlusion : Complete(C), Partial(P)
    - Division : Complete(C), Partial(P), Loss of substance(LS)
    - Vasculobiliary injury (VBI)
  - TO : Time of detection
    - Early(E)
      - Early intraoperative(Ei)
      - Immediate postoperative(Ep)
    - Late(L)
  - M : Mechanism
    - Mechanical (Me)
    - Energy driven (ED)

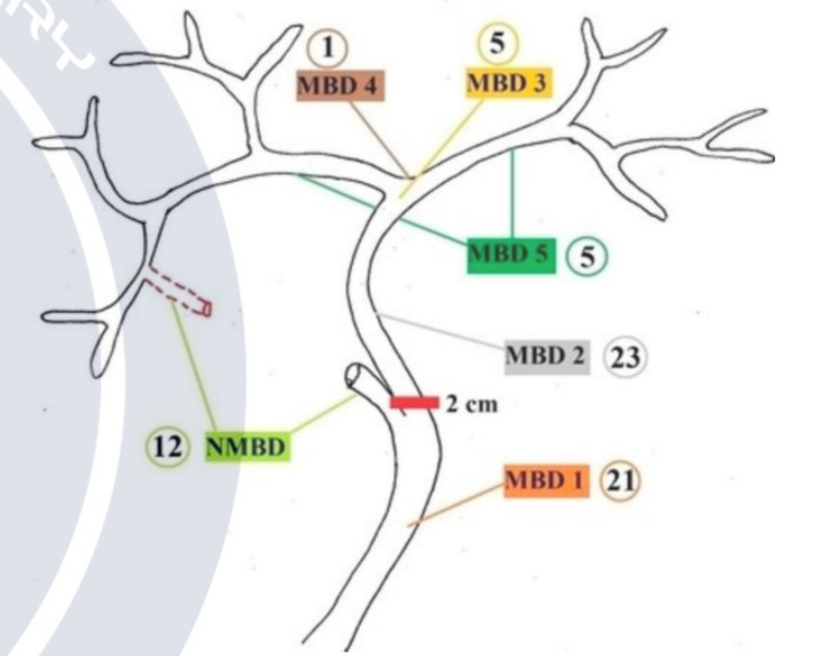

Fig. 1. Anatomic levels of bile duct injuries: NMBD – nonmain biliary duct, MBD1 – ≥ 2 cm from lower border of superior biliary confluent, MBD2 – < 2 cm from lower border of superior biliary confluent, MBD3 involves the superior biliary confluent but communication right left is preserved, MBD4 involves superior biliary confluent but communication right left is interrupted, MBD5 right or left hepatic duct.

A. Fingerhut et al. ATOM, the all-inclusive, nominal EAES classification of bile duct injuries during cholecystectomySurg Endosc (2013) 27:4608–4619

Audrius Šileikis, et al. B. POL PRZEGL CHIR, 2019: 91 (1), 14-21

Table 2 EAES classification matrix for bile duct injuries

Anatomical characteristics							Time of detection			Mechanism	
Anatomic level	Type and extent of injury					Vasculobiliary injury (yes=VBI+) and name of injured vessel (RHA, LHA, CHA, PV, MV); (no = VBI-)	Ei (de visu, bile leak, IOC)	Ep	L	Me	ED
	occlusion		division								
	C	P*	C	P*	LS**						
MBD											
1											
2											
3											
4											
5											
6											
NMBD											

For each injury, the surgeon fills in the following matrix: (1) single injury (yes/no); (2) multiple injuries (yes/no). Then one matrix is filled in for each injury, as appropriate. For example, an injury made by an energy-driven (ultrasonic) dissector involving the superior biliary confluence with interruption of the right and left hepatic ducts, detected (intraoperatively) during the operation by the presence of bile would be classed as MBD 4 C VBI Ei, ED. The Connor Garden E6 injury is in fact a type 4 with LS: MBD 4 LS

EAES European Association for Endoscopic Surgery, *MBD* main biliary duct, *NMBD* nonmain biliary duct (Luschka duct, aberrant duct, accessory duct), *level 1* $\geq$ 2 cm from lower border of superior biliary confluent, *level 2* < 2 cm from lower border of superior biliary confluent, *level 3* involves the superior biliary confluent but communication right left is preserved, *level 4* involves superior biliary confluent but communication right left is interrupted, *level 5a* right or left hepatic duct, *level 5b* right sectorial duct but bile duct still in continuity, *C* complete, *P* partial, *LS* loss of substance, *Me* mechanical, *ED* energy driven, *VBI* vasculobiliary involvement, *RHA* right hepatic artery, *LHA* left hepatic artery, *CHA* common hepatic artery, *PV* portal vein, *MV* marginal vessels, *Ei* early intraoperative, *Ep* early postoperative, *L* late, *OC* intra-operative cholangiogram

[a] Indicate percentage of circumference, if known

[b] Indicate length, if known

A. Fingerhut et al. ATOM, the all-inclusive, nominal EAES classification of bile duct injuries during cholecystectomySurg Endosc (2013) 27:4608–4619

Classification

Table 2 Summary of the most commonly used BDI classification systems

	BDI classification systems								
	Bismuth [92, 93]	**Strasberg [90]**	**McMahon [94]**	**Bergman [95]**	**Csendes [97]**	**Stewart-Way [98, 103]**	**Hannover [17]**	**Lau [99]**	**ATOM [100]**
Bile leakage									
Cystic duct leak or leaks from small ducts in liver bed		A		A	Type I		Type A	Type 1	NMBD
Occlusion of an aberrant RHD		B						Type 2	
Leak from an aberrant RHD		C							
Lateral injury to CBD < 50% diameter		D						Type 2	
Laceration > 25% of CBD			Major bile duct injury	B					
Transection of CBD or CHD			Major bile duct injury	D	Type III	Class II/III	Type D	Type 3	
Resection od more than 10 mm of the CBD					Type IV				
Tangential injury of the CBD							Type C		
Right/left hepatic duct or sectoral duct injuries								Type 4	
Laceration < 25% of CBD			Minor bile duct injury			Class I			
Laceration of cystic-CBD junction			Minor bile duct injury		Type II				
Bile stricture									
Stenosis of the main bile duct without injury (caused by a clip)							Type B		
CBD stump > 2 cm	Type I	EI							MBD 1
CBD stump < 2 cm	Type II	E2							MBD 2
Ceiling of the biliary confluence is intact	Type III	E3							MBD 3
Ceiling of the confluence is destroyed	Type IV	E4							MBD 4
Type I, II or III + stricture of an isolated right duct	Type V	E5							
Development of post-operative CBD stricture			Major bile duct injury	C			Type E		
Vascular lesion									
Right hepatic artery + RHD transected						Class IV	Type D	Type 5	VBI

RHD right hepatic duct, *CBD* common bile duct, *CHD* common hepatic duct, *NMBD* non-main bile duct, *MBD* main bile duct, *VBI* vasculobiliary injury

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Prevention

WSES

Statements	Grade
1.1. The use of the CVS during LC (achieving all 3 components) is the recommended approach to minimize the risk of BDIs.	1C
1.2. If the CVS is not achievable during a difficult LC, a bailout procedure, such as STC, should be considered.	1B
1.3. Conversion to open surgery may be considered during a difficult LC whenever the operating surgeon cannot manage the procedure laparoscopically. However, there is insufficient evidence to support conversion to open surgery as a strategy to avoid or reduce the risk of BDI in difficult LCs.	2B
1.4. Intraoperative IOC is useful to recognize bile duct anatomy and choledocholithiasis in cases of intraoperative suspicion of BDI, misunderstanding of biliary anatomy, or inability to see the CVS, but routine use to reduce the BDI rate is not yet recommended.	2A
1.5. Intraoperative ICG-C is a promising noninvasive tool to recognize bile duct anatomy and vascular structures, but routine use to reduce the BDI rate is not yet recommended.	2C
1.6. In patients presenting with AC, the optimal timing for LC is within 48 h, and no more than 10 days from symptom appearance.	1A
1.7. In patients with at-risk conditions (e.g., scleroatrophic cholecystitis, Mirizzi syndrome), an exhaustive preoperative work-up prior cholecystectomy is mandatory in order to discuss and balance the risks/benefits ratio of the procedure.	2C

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Prevention

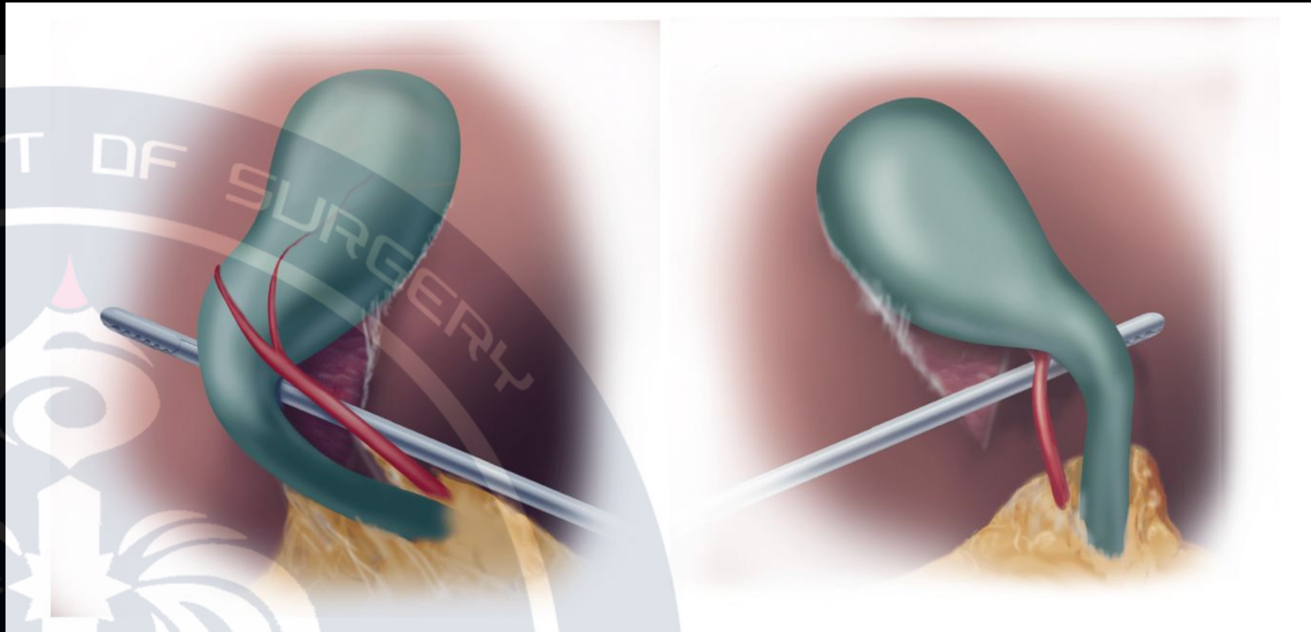
SAGES suggested Strategies for Minimizing Bile Duct Injuries: Adopting a Universal Culture of Safety in Cholecystectomy

1. Use the Critical View of Safety (CVS) method of identification of the cystic duct and cystic artery during laparoscopic cholecystectomy
2. Understand the potential for aberrant anatomy in all cases
3. Make liberal use of cholangiography or other methods to image the biliary tree intraoperatively
4. Consider an Intra-operative Momentary Pause during laparoscopic cholecystectomy prior to clipping, cutting or transecting any ductal structures
5. Recognize when the dissection is approaching a zone of significant risk and halt the dissection before entering the zone. Finish the operation by a safe method other than cholecystectomy if conditions around the gallbladder are too dangerous
6. Get help from another surgeon when the dissection or conditions are difficult

The SAGES Safe Cholecystectomy Program. https://wwwsages.org/safe-cholecystectomy-program/. Accessed 1 Oct 2018

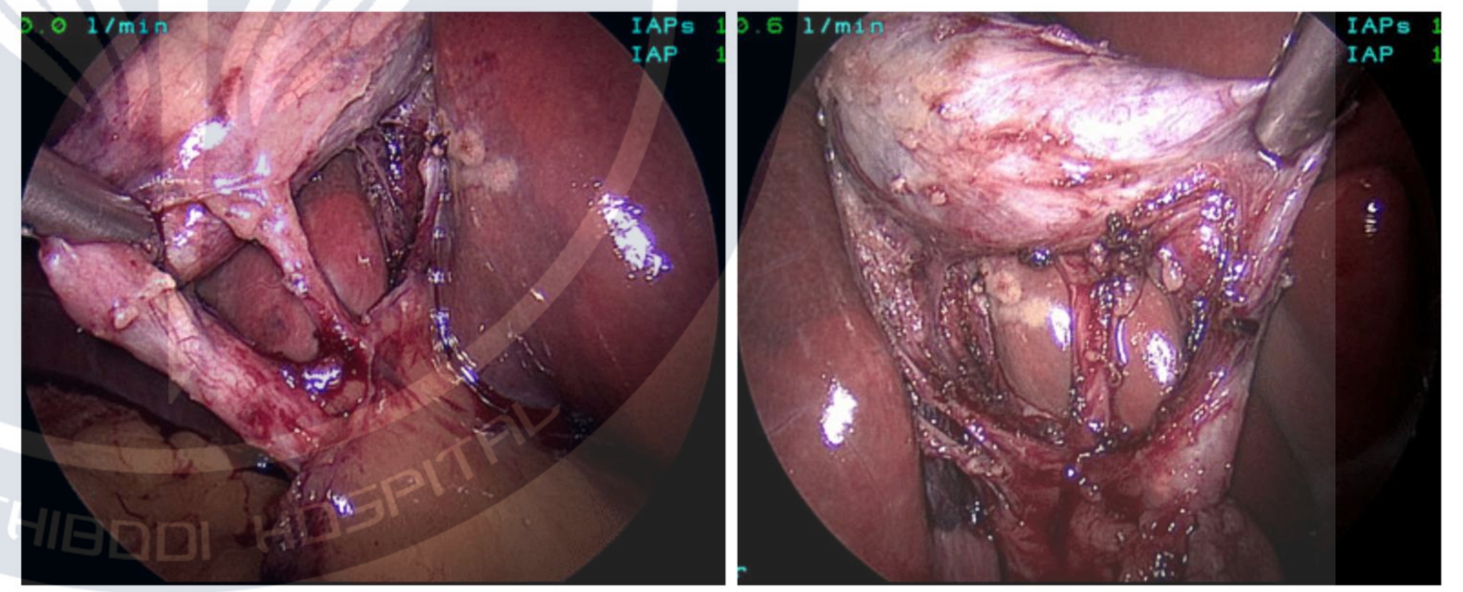
Prevention

- Critical view of safety
  1. The hepatocystic triangle is cleared of fat and fibrous tissue
     - CHD
     - Cystic duct
     - Inferior edge of the liver
  2. The lower 1/3 of the gallbladder is separated from the liver to expose the cystic plate
     - The cystic plate is known as liver bed of the gallbladder and lies in the gallbladder fossa
  3. Two and only two structures should be seen entering the gallbladder



Critical view of safety anterior view

Critical view of safety posterior view



Visualization of the doublet view (anterior)

Visualization of the doublet view (posterior)

The SAGES Safe Cholecystectomy Program. https://wwwsages.org/safe-cholecystectomy-program/. Accessed 1 Oct 2018

Prevention

- R4U line
  - Rouviere's sulcus
    - Under surface of the right lobe of the liver, running to the right of the hepatic hilum
    - Contains right portal pedicle or its branches
  - Segment 4
    - Left medial section of the liver
    - Fixed landmark for guiding dissection cephalad to R4U line
  - Umbilical fissure
    - Fissure between the left lateral section and left medial section (segment 4) where the falciform ligament and ligamentum teres lie
    - Fixed anatomical landmark, and helps the operating surgeon to reorient in difficult situations

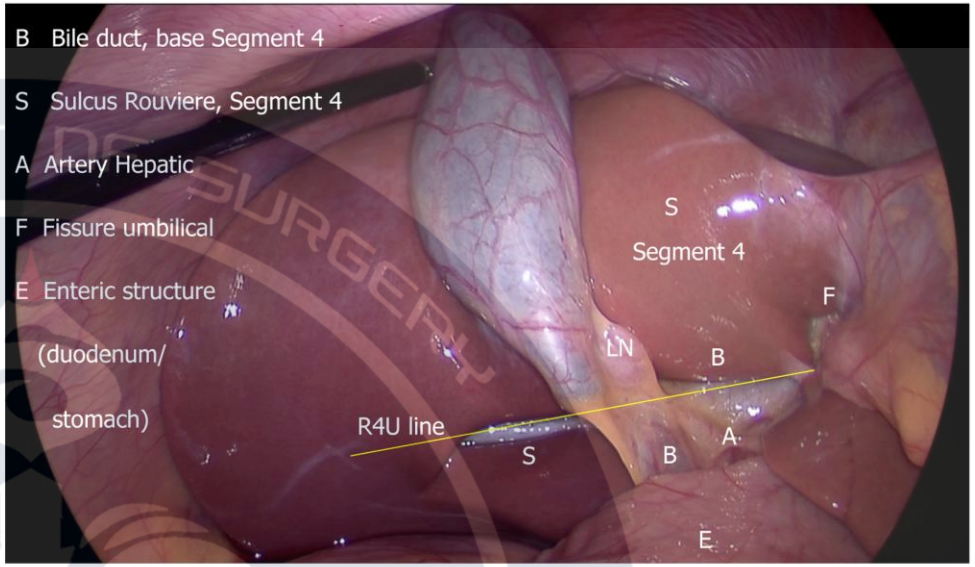


Figure 4 B-SAFE anatomical landmarks and R4U safety line. If Rouviere's sulcus is not present, then the imaginary line passing across the base of the segment 4 from the umbilical fissure may be extended towards right across the hepatoduodenal ligament to ascertain safe zone of dissection (Figure 5).

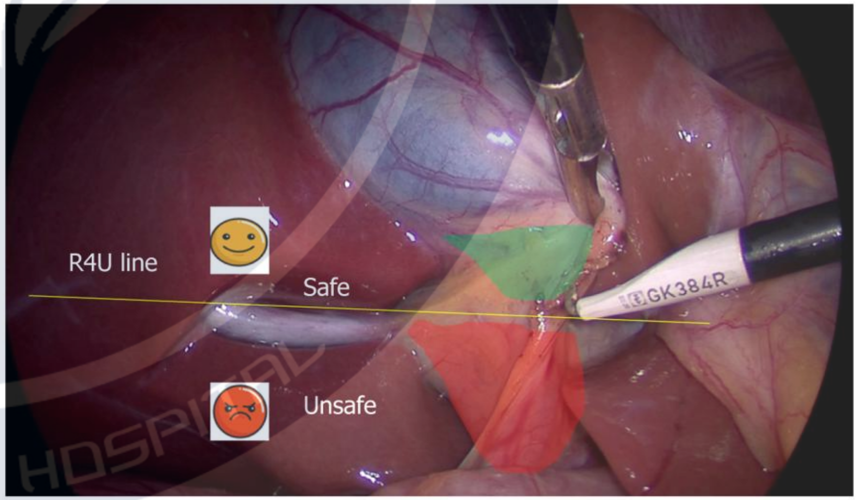


Figure 5 Surgical field of interest during laparoscopic cholecystectomy. It is important to identify safe (green) and danger (red) zones of dissection as demarcated by R4U line.

Gupta V, Jain G. Safe laparoscopic cholecystectomy: Adoption of universal culture of safety in cholecystectomy. World J Gastrointest Surg 2019; 11(2): 62-84

Prevention

- Biliary ductal anomalies
  - In case of unsured ductal anomalies : anatomy should be clarified
    - IOC, ICG

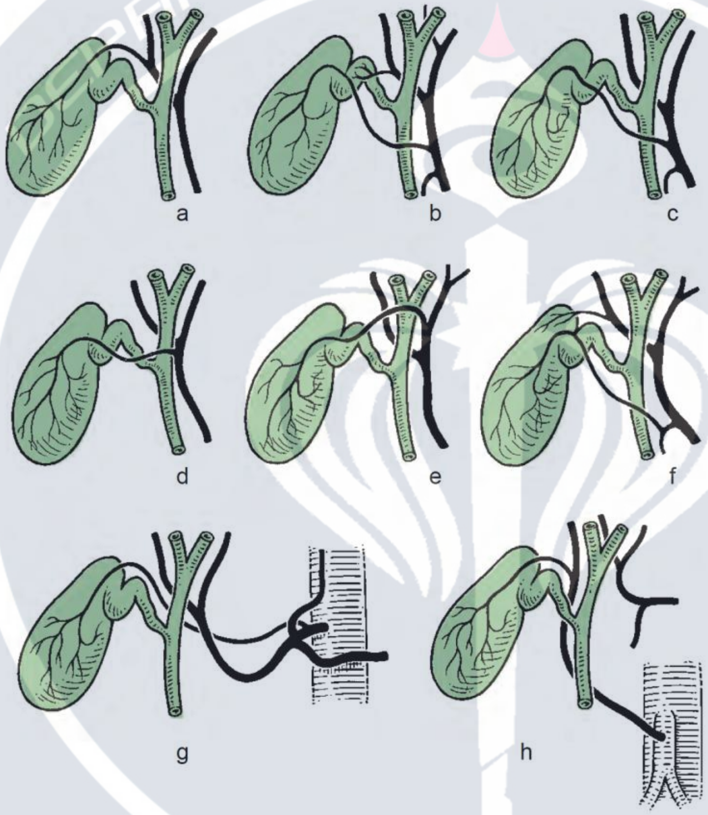


FIGURE 2.22 The main variations of the cystic artery: typical course *(a)*, double cystic artery *(b)*, cystic artery crossing anterior to main bile duct *(c)*, cystic artery originating from the right branch of the hepatic artery and crossing the common hepatic duct anteriorly *(d)*, cystic artery originating from the left branch of the hepatic artery *(e)*, cystic artery originating from the gastroduodenal artery *(f)*, cystic artery arising from the celiac axis *(g)*, and cystic artery originating from a replaced right hepatic artery *(h)*.

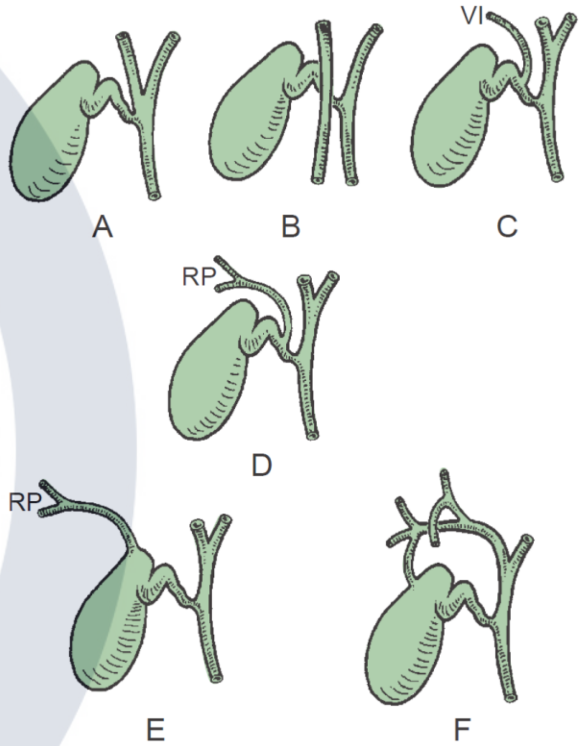


FIGURE 2.27 The main variations of ectopic drainage of the intrahepatic ducts into the gallbladder and cystic duct. A, Drainage of the cystic duct into the biliary confluence. **B,** Drainage of cystic duct into the left hepatic duct, associated with no biliary confluence. **C,** Drainage of segment VI duct into the cystic duct. **D,** Drainage of the right posterior *(RP)* sectional duct into the cystic duct. **E,** Drainage of the distal part of the right posterior sectional duct into the neck of the gallbladder. **F,** Drainage of the proximal part of the right posterior sectional duct into the body of the gallbladder.

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Prevention

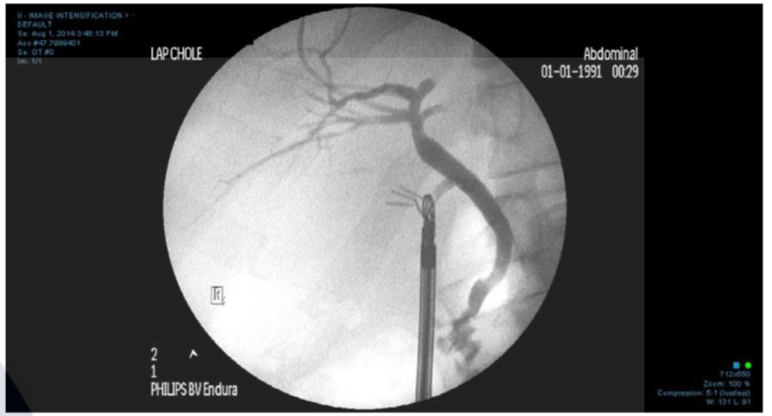


FIGURE 2: *Normal intraoperative cholangiogram showing contrast flow into intrahepatic ducts.*

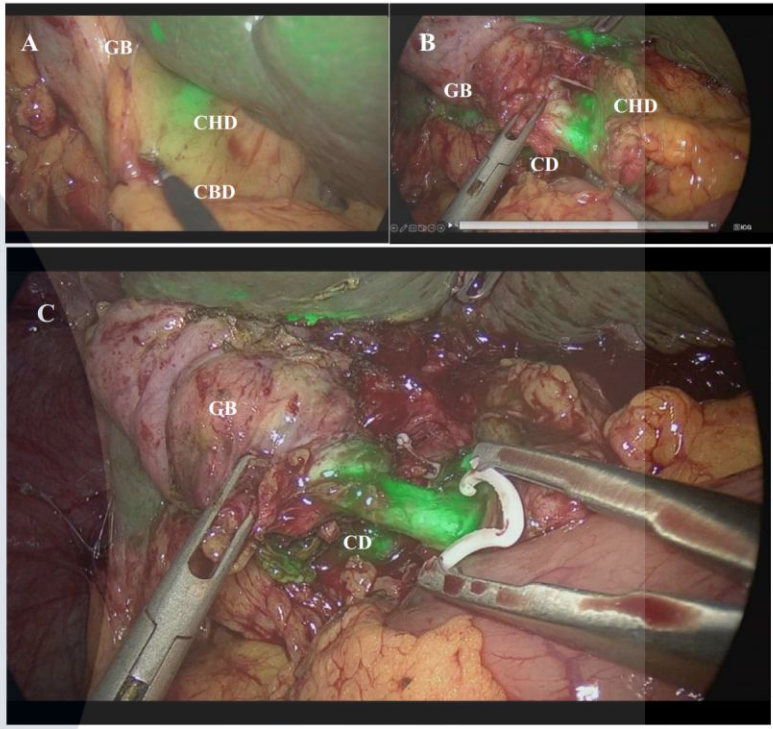
- Intraoperative cholangiography
  - Intraoperative assessment of the biliary anatomy, identification and assessment of extent of biliary injury, and possible prevention of biliary ductal injury
  - Several large retrospective data sets report association of IOC with lower rates of BDI
  - 90%–95% success rate, and has the additional advantage of detection of asymptomatic CBD stones
  - Ductal cannulation can be difficult in patients with short and thin cystic ducts
  - Routine use is still controversy

Gupta V, Jain G. Safe laparoscopic cholecystectomy: Adoption of universal culture of safety in cholecystectomy. World J Gastrointest Surg 2019; 11(2): 62-84
S. VERMA ET AL. Aust. J. Rural Health (2016) 24, 415–421

Prevention

- Intraoperative ultrasonography
  - Useful in detecting vascular injury
- Near-infrared fluorescent cholangiography
  - Most recent addition to the armamentarium for intraoperative assessment of biliary tract
  - Takes less time comparing to IOC
  - Routine use is still controversy

Fig. 1 Intraoperative identification of extrahepatic bile ducts with near-infrared fluorescence cholangiography mode, Legend: *GB*: gallbladder, *CD* cystic duct, *CBD* common bile duct, *CHD* common hepatic duct



Legend: GB: gallbladder; CD: cystic duct; CBD: common bile duct; CHD: common hepatic duct;

Gupta V, Jain G. Safe laparoscopic cholecystectomy: Adoption of universal culture of safety in cholecystectomy. World J Gastrointest Surg 2019; 11(2): 62-84
P. Losurdo et al.European Journal of Trauma and Emergency Surgery (2024) 50:275–281

Prevention

- Bailout techniques/strategies
  1. Abort the procedure altogether
     - Dense pericholecystic adhesions due to severe acute or chronic inflammation with non-visualization of gallbladder -> post op reattempting in 2-3 mo
  2. Convert to an open procedure
     - Difficult procedure may remain difficult even after conversion to open with no effect on postoperative complications
     - 100 fold increase in BDI rate in converted cases
  3. Tube cholecystostomy
     - Bridge procedure for later cholecystectomy
     - Difficult for interval LC with high conversion rate
  4. Subtotal cholecystectomy (STC, open/laparoscopic)
  5. Fundus first cholecystectomy

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Prevention

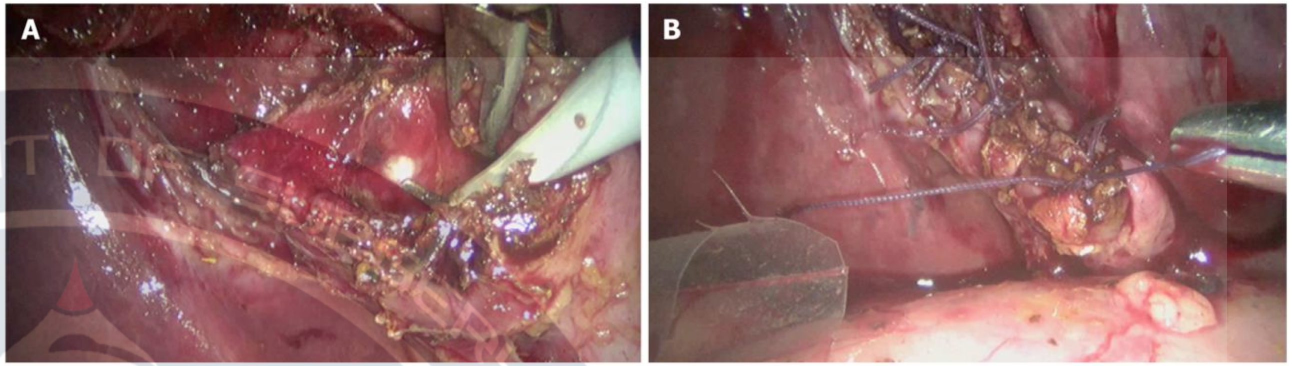

Figure 14 Laparoscopic subtotal cholecystectomy (reconstituting) as a bailout procedure. A: Mucosa of the gallbladder stump is fulgurated after removal of as much gallbladder as safely possible; B: Stump is closed after ensuring no stone is left behind in this stump.

- Bailout techniques/strategies
  4. Subtotal cholecystectomy (STC, open/laparoscopic)
     - Leaving behind a part of the gallbladder : Safer than a difficult dissection in the HC triangle
       - Remove all the stones from the gallbladder
       - Ablate the mucosa of the gallbladder stump (with diathermy or argon plasma coagulator)
       - Leave stump as small as possible
     - Stump can be closed with suture or staple
  5. Fundus first cholecystectomy
     - Dissection must remain very close to the gallbladder wall
     - Can facilitate performing subtotal cholecystectomy

Gupta V, Jain G. Safe laparoscopic cholecystectomy: Adoption of universal culture of safety in cholecystectomy. World J Gastrointest Surg 2019; 11(2): 62-84

Timing of recognition

Intraoperative detection

- Early recognition of bile duct injuries is very important : the earlier the recognition, the better the outcomes
  - Presence of unexplained source of bile -> BDI must be suspected
  - Selective use of adjuncts for biliary tract visualization (e.g., IOC, ICG-C) during difficult LC or whenever BDI is suspected
  - Conversion to open surgery may be also considered in the event of BDI during LC

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Management

Intraoperative management

- Management depends on injury extent and classification
- Analyze the injury and choose between
  - Immediate repair
  - Drain now and fix later
- For minor BDIs (i.e., Strasberg A–D and conditionally E2)
  - Direct repair, with or without the placement of a T-tube + placement of abdominal drains
  - On site endoscopic decompression might be considered in Strasburg A

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Management

Intraoperative management

- For major BDIs (i.e., Strasberg E) associated with tissue loss and whenever an ischemic injury is suspected
  - Roux-en-Y hepaticojejunostomy for reconstruction
  - End-to-end anastomosis
    - T-tube insertion in healthy tissue proximal or distal to injury can decrease stricture incidence
  - Insufficient experience in HPB surgery
    - Drain placement in the right upper quadrant + refer to the center with experienced HPB surgeons
  - Conversion to an open surgery to solely confirm diagnosis or perform injury staging is not recommended

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Management

- Vasculobiliary injury
  - Hepatic blood supply : Mainly portal vein
    - Interruption of RHA alone is usually well tolerated
  - Immediate repair of the right hepatic artery is not the most frequent option even in tertiary care centers
  - Liver ischemia in 10% of cases
  - Management depends on the evidence and extent of the liver injury (e.g., ischemia, necrosis, or atrophy)
    - Stabilization may require few weeks or months
    - Delayed surgical management to allow for an accurate imaging workup and strategic planning

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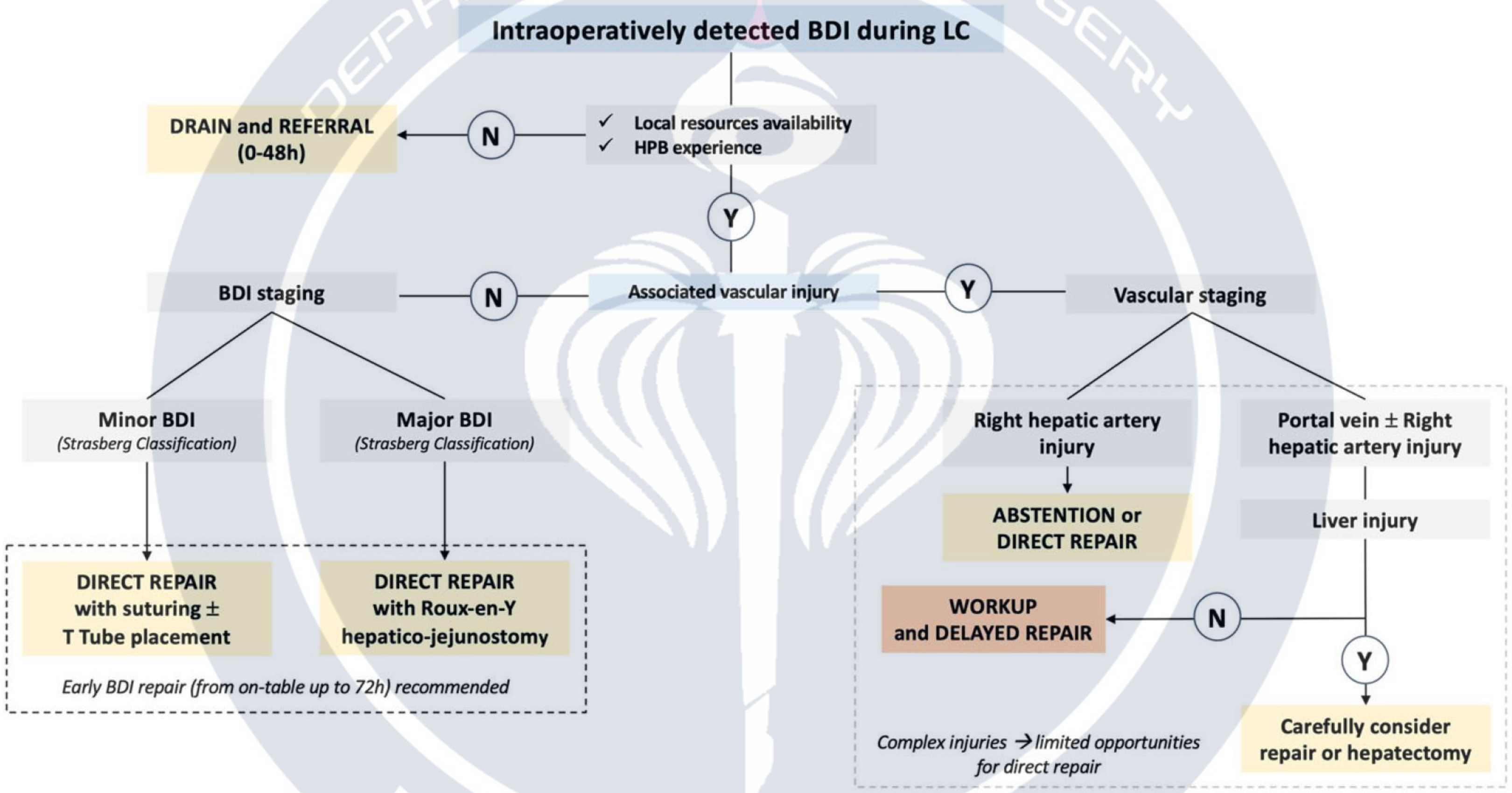

Fig. 1 Decisional tree in case of intra-operatively detected BDI. *N stands for no, Y for yes*

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Timing of recognition

Postoperative diagnosis

- Most frequent presentation
  - Bile leakage : From drain or surgical incision
    - Biloma, abscess or bile peritonitis
  - Biliary obstruction : cholestatic jaundice
    - Symptoms often delayed
- Prompt investigation of patients
  - Not rapidly recover after LC
  - Alarm symptoms : fever, abdominal pain, distention, jaundice, nausea, and vomiting
- Clinical course of undiagnosed or unrepaired BDI can evolve to secondary biliary cirrhosis with portal hypertension, liver failure, and death

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Investigation

- Ultrasonography
  - Primary noninvasive
  - Easily available diagnostic tool
  - Detection of
    - Intra-abdominal fluid collections
    - Dilation of the biliary ducts
    - Associated vascular lesions by using Doppler evaluation

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Investigation

- Computed tomography
  - Identify the presence of
    - Focal intra- or perihepatic fluid collections, ascites, biliary obstruction with upstream dilation
    - Long-term sequelae of a longstanding bile stricture, such as lobar hepatic atrophy or signs of secondary biliary cirrhosis
    - Associated vascular lesions, such as injury to the right hepatic artery
  - Disadvantage
    - Cannot distinguish bile leaks from postoperative collection or blood
    - Cannot precisely locate the leakage site

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Investigation

- Hepatobiliary Scintigraphy
  - More sensitive and specific than U/S and CT in detecting bile leakage
  - Identify the relationship between the leak and fluid collection
    - Show the primary route of bile flow
  - Disadvantage
    - The resolution is poor to identify the location
    - Extrabiliary structures are not visualized
    - Poor sensitivity in patients with hepatic dysfunction and large bile duct defects with preferential bile flow in a path of least resistance

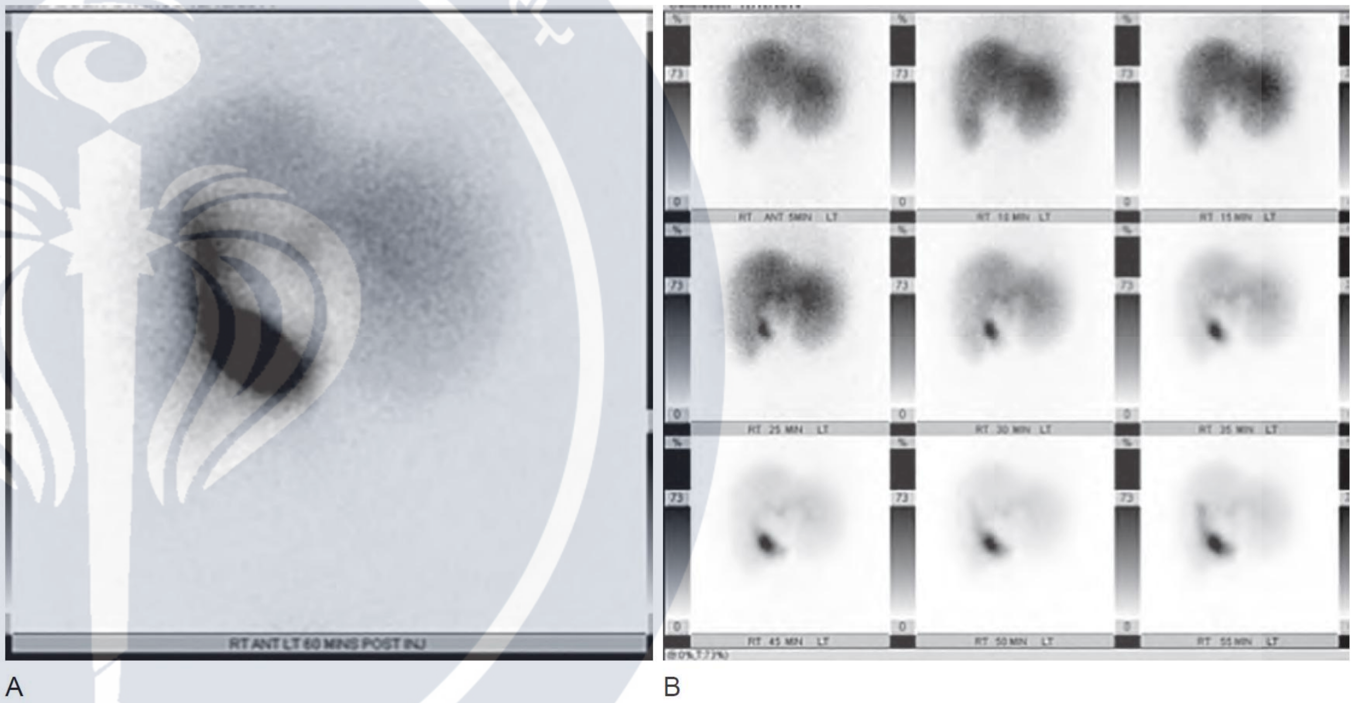

FIGURE 42.24 A hepatobiliary iminodiacetic acid scan was obtained several days after biliary injury. After 60 minutes, there is contrast retention in an isolated sectoral duct, suggestive of stricture causing delayed biliary excretion (see Chapter 18).

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Investigation

- ERCP or PTC
  - Identify a continuing bile leak
  - Provide exact anatomical diagnosis
  - Treatment of the injury by decompressing or dilating the biliary tree
  - PTC in case of ERCP failure
    - Option to accurately depict the location and nature of BDI
    - Perform an extraluminal percutaneous endoscopic rendezvous procedure with stent placement to restore continuity of the bile duct
  - Disadvantage
    - Invasive techniques -> Risk of complications : severe acute pancreatitis (mainly after ERCP), bleeding, and cholangitis (after PTC)
    - Lack of detection of extrabiliary abnormalities and the non-visualization of ducts upstream or downstream from an obstructing lesion (e.g., stricture, stone)
    - PTC can be technically difficult in non-dilated duct

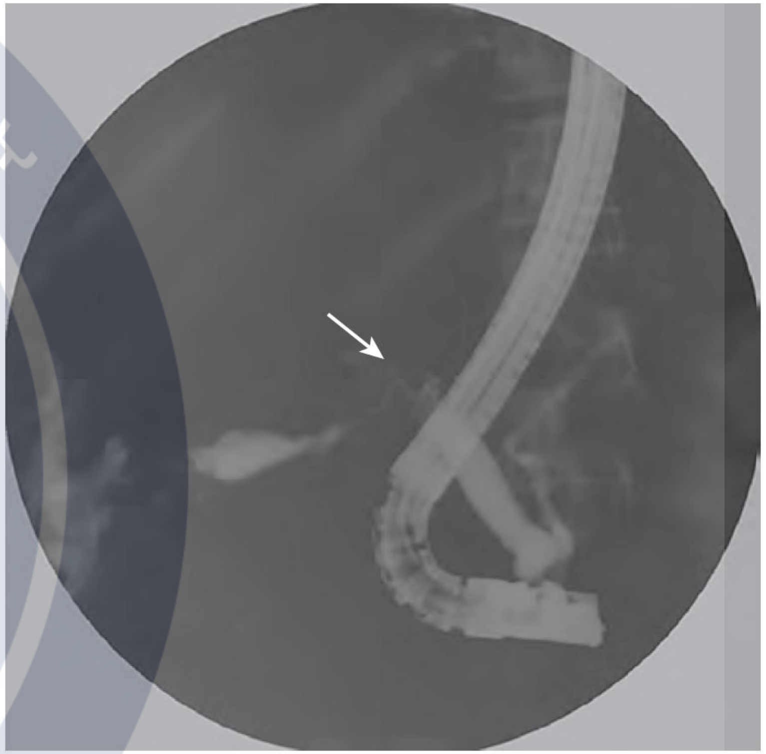

FIGURE 42.25 After transection of the bile duct in this patient, an endoscopic retrograde cholangiopancreatography was undertaken with deployment of biliary stents. Contrast is noted to extravagate from the blind end at the site of transection *(arrow)*.

de Angelis et al. 2020 WSES guidelines for the detection and management of bile duct injury during cholecystectomyWorld Journal of Emergency Surgery (2021) 16:30
BLUMGART'S Surgery *of the* Liver, Biliary Tract and Pancreas. 7th ed. 2023

Investigation

- MRI
  - Gold standard for complete evaluation of the biliary tree : proximal and distal to the level of injury
  - Functional assessment of the biliary tree, detection and localization of bile leaks with an accuracy close to 100%
  - CE-MRCP increased the sensitivity, specificity, and accuracy, with respective ranges (depending on the bile leak etiology)
    - CE-MRCP : 76–82%, 100%, and 75–91%
    - Conventional MRCP : 53–63%, 51–66%, and 55–63%

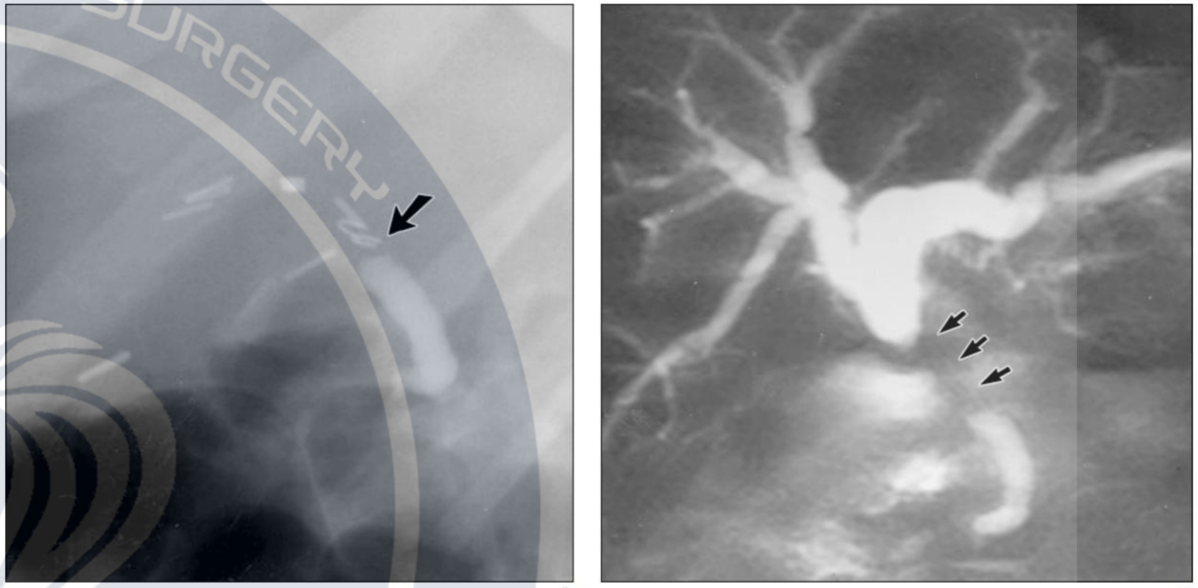

Fig. 3.—Excision injury with ligation in 35-year-old woman who presented 1 week after laparoscopic cholecystectomy with right upper quadrant pain and jaundice. **A,** Endoscopic retrograde cholangiopancreatographic image shows distal one third of bile duct with abrupt cutoff (*arrow*) and multiple surgical clips in subhepatic area. **B,** MR cholangiopancreatogram shows moderate intrahepatic biliary dilatation and cutoff 1 cm distal to bifurcation caused by ligation injury. Segment of extrahepatic bile duct 1.8 cm long is missing (*arrows*), a finding consistent with excision injury.

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Khalid et al. AJR:177, December 2001

Management

Postoperative diagnosed management

- Management is based on multiple factors
  - Complexity of the biliary injury
  - Severity of clinical presentation
  - Patient’s fitness and comorbidities
  - Availability of a skilled surgeon with expertise in HPB surgery
- In all cases, a multidisciplinary approach involving interventional radiologists, gastroenterologists, and surgeons is advocated

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Management

Postoperative diagnosed management

- Minor BDI (Strasberg A-D)
  - Bile leakage from drain -> non-operative management and observation as the initial management
  - In case of no drain placement and imaging showed bile collection with suspicion of minor BDI
    - Percutaneous drainage as the definitive treatment
  - In case of no-improving or deteliorated symptoms -> Endoscopic management : ERCP c stent

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Management

- Endoscopic management : ERCP
  - Allows identification of leakage site and internal stenting
  - At least partially documented continuity of the BDI (at the MRCP) or a very close proximity of the two biliary stumps (the proximal and the distal stumps)
  - Success rate 87.1 – 100% depending on grading and location of the leak
  - Bile leaks are divided into categories
    - Low grade : Leak can only be identified after complete opacification of the intrahepatic biliary system
    - High grade : Leak can be observed before intrahepatic opacification
  - Leaks that respond more favorably to endoscopic treatment are those located at the end of a cystic duct stump or from a duct of Luschka
    - Usually associated with low output

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Management

- Endoscopic management : ERCP
  - Main goals : reduce the transpapillary pressure gradient to facilitate preferential bile flow through the papilla as opposed to the site of the leak, providing time to the biliary tree injury to heal
    - Sphincterotomy
    - Biliary stent
    - Naso-biliary stent – low compliance
  - Plastic stents are recommended for treating bile leak
    - For refractory bile leaks -> Fully covered self-expanding metallic stent was superior to multiple plastic stents
  - Stents were placed 4-8 wks -> removed after cholangiogram showed no leakage

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Open Access

Endoscopic Management of Bile Leakage after Cholecystectomy: A Single-Center Experience for 12 Years

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- Retrospective review of 32 patients underwent ERCP due to bile leakage after cholecystectomy
- Evaluate the efficacy of endoscopic management
- All patients were discharged w/o clinical evidence of leakage and 2nd look ERCP was done at 4-6 wk later

Table 2. Outcomes of Endoscopic Management of Bile Leak

Types of treatment	No. of patients (*n*=32)	Sites of leak: Cystic duct (*n*=25)	Rt /Lt IHD (*n*=3/1)	CBD (*n*=1)	Liver bed (*n*=2)	Leak healed
ERBD without ES	8 (25.0)	5	1/0	0	2	8 (100)
ERBD with ES						
Without PCD	18 (56.2)	16	1/0	1	0	18 (100)
With PCD	3 (9.4)	2	0/1	0	0	3 (100)
ERBD after ENBD with ES[a)]	1 (3.1)	0	1/0	0	0	1 (100)
Surgery[b)]	2 (6.3)	2	0/0	0	0	0 (0)

Values are presented as number (%).
Rt, right; Lt, left; IHD, intrahepatic duct; CBD, common bile duct; ERBD, endoscopic retrograde biliary drainage; ES, endoscopic sphincterotomy; PCD, percutaneous drainage; ENBD, endoscopic nasobiliary drainage.
[a)]ERBD was performed due to a persistent bile leak after ENBD placement with ES; [b)]One patient underwent open laparotomy because of a deteriorating bile leak after PCD insertion and ERBD placement with ES due to bile leak at the cytic dut stump initially. In the operation field, an ongoing bile leak was identified from the right hepatic duct, and eventually the patient underwent hepaticojejunostomy. Another one underwent hepaticojejunostomy due to the complete occlusion of mid-CBD combined with massive bile leak.

Table 1. Baseline Characteristics of 32 Cases

Parameter	Value
Age, yr	60.9±15.4 (20–87)
Sex, male/female	20/12 (62.5/37.5)
Causes of operation	
Acute calculous cholecystitis	17 (53.1)
Acute acalculous cholecystitis	7 (21.9)
Gallbladder empyema	7 (21.9)
Gallbladder polyp	1 (3.1)
Types of operation	
LC/OC/LC conversion to OC	18 (56.3)/12 (37.5)/2 (6.3)
Diagnostic method of bile leak	
Bile drainage through Hemovac	22 (68.8)
Abdominal pain	6 (18.8)
Fever	2 (6.3)
Ascites	1 (3.1)
Jaundice	1 (3.1)
Site of bile leak	
Cystic duct stump	25 (78.1)
Rt/Lt IHD	3/1 (9.4/3.1)
Liver bed	2 (6.3)
Common bile duct	1 (3.1)
Types of injury	
Leak only	28 (87.5)
Leak combined with ductal stricture	4 (12.5)
Severity of leak	
Low grade/High grade	18 (56.3)/14 (43.8)
Time interval, day	
Cholecystectomy to bile leak	5.3±5.1 (1–21)
Bile leak to ERCP	3.7±4.1 (1–15)
ERCP to stent removal[a)]	55.7±35.8 (17–174)

Values are presented as mean±SD (range) or number (%).
LC, laparoscopic cholecystectomy; OC, open cholecystectomy; Rt, right; Lt, left; IHD, intrahepatic duct; ERCP, endoscopic retrograde cholangiopancreatography.
[a)]It excluded four patients (12.5%) exhibiting spontaneous stent disappearance at follow-up.

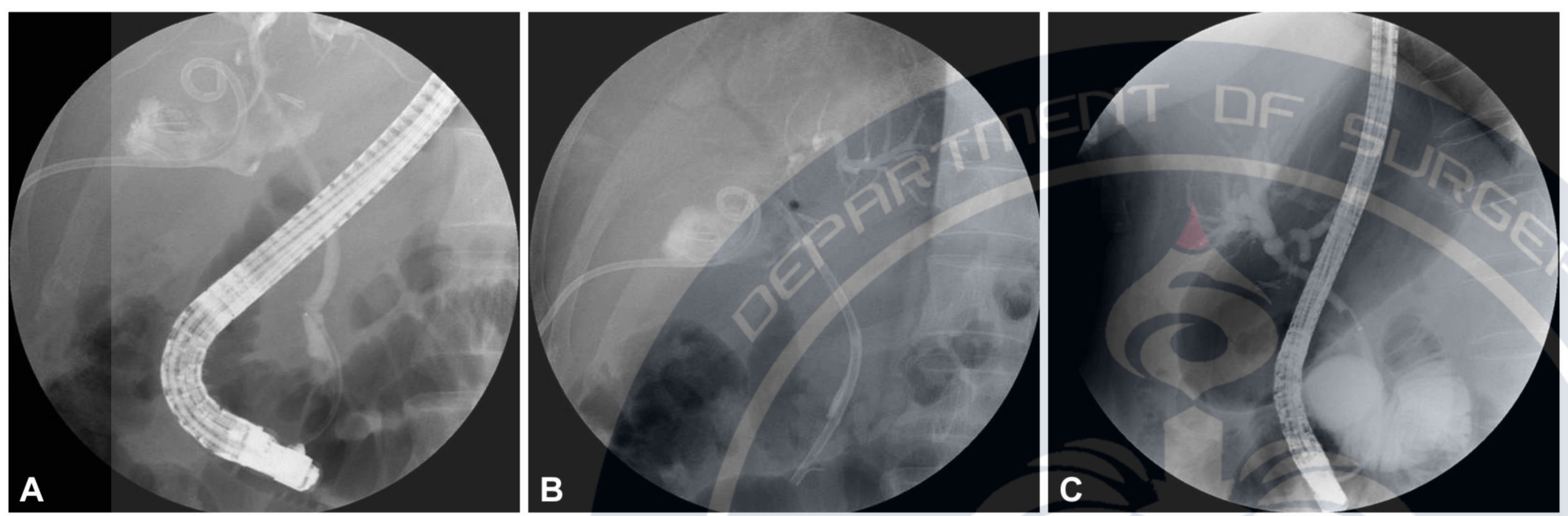

Fig. 1. Endoscopic retrograde cholangiopancreatogram and follow-up cholangiogram of a cystic stump bile leak. (A) Extravasation of contrast was observed in the region of the cystic duct stump by cholangiography. Percutaneous catheter for the drainage of the biloma is also noted. (B) A plastic stent (10 Fr, 7 cm) was placed through the ampullary orifice. (C) No bile leak was evident after stent removal 6 weeks later.

- Overall success rate 93.8 %
- No important procedure related complications were encountered
- ERCP should be considered as primary role for diagnosis and treatment for bile leak after cholecystectomy

Table 3. Types of Plastic Stents for Bile Leak

Variable	No. of patients (n=32)
Size, Fr	
10/11.5	23/9 (71.9/28.1)
Length, cm	
5/7/9	9/16/7 (28.1/50.0/21.9)
Shape	
Straight/Double pig tail	32/0 (100/0)
Location of stents	
Proximal/Distal to leak site	17/15 (53.1/46.9)

Values are presented as number (%).

Table 4. Complications of Endoscopic Management of Bile Leak

Parameter	No. of patients
ERBD related	
Internal migration	1 (3.1)
Occlusion with cholangitis	1 (3.1)
Pancreatitis	2 (6.3)

Values are presented as number (%).
ERBD, endoscopic retrograde biliary drainage.

Management

- Benign bile duct stricture
  - Early postoperative period stricture : due to surgical trauma (energy device)
  - More responds to endoscopic treatment than fibrotic stricture
  - Biliary stents : multiple plastic stents over the long period is the preferred treatment (success rate 74-90%)
    - Stricture locating >2 cm from confluence -> FCSEMS can be an alternative
  - Unsuccessful ERCP -> PTBD
    - PTBD in the presence of bile leakage may be more difficult as a result of non-dilated bile ducts
    - Technical success of 90% and a short-term clinical success of 70–80% in expertise centers

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Management

Postoperative diagnosed management

- Major BDI (Strasberg E) : Complete loss of common and/or hepatic bile duct continuity
  - Carefully planned surgical treatment is required
  - Early aggressive surgical repair (performed within 48 h from diagnosis)
    - Good results, avoid the onset of sepsis, and provide advantages in terms of reduced costs and rate of hospital readmissions
  - After 48–72 h, while inflammation tends to decrease, the phase of proliferation and healing begins and further complicates surgical repair
  - 1-week delay in the diagnosis of major BDIs suggests the need for a “timeout” of 2–3 months before intervention

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Management

Postoperative diagnosed management

- Major BDI (Strasberg E)
  - Biliary peritonitis, urgent surgical intervention is required
    - Laparoscopic lavage of the abdominal cavity and drain placement
  - After stabilization + resolution of acute inflammatory phase(several weeks : 2–3 weeks)
    - Lowering the risks associated with extensive reconstructive surgery by reducing inflammation
    - Good assessment of the extent of ischemic injury resulting from associated vascular injuries

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Management

Postoperative diagnosed management

- Major BDI (Strasberg E)
  - Timing between 72 h and 3 weeks
    - Percutaneous drainage of the fluid collections whenever present
    - Targeted antibiotics
    - Nutritional support
    - ERCP (sphincterotomy with or without stent) can be considered to reduce the pressure gradient in the biliary tree
    - PTBD could be useful for septic patients with a complete obstruction of the common bile duct
    - After a minimum of 3 weeks, if the patient’s general conditions allow and the acute or subacute situation is resolved (e.g., closure of the biliary fistula) -> Roux-en-Y hepaticojejunostomy should be performed
  - When major BDIs are recognized late after the index LC and there are clinical manifestations of stricture, Roux-en-Y hepaticojejunostomy should be performed

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Management

Postoperative diagnosed management

- Major BDI (Strasberg E)
  - An end-to-end anastomosis may be performed if technically possible
    - Associated with increased failure rates : stricture
  - Roux-en-Y bilioenteric anastomosis represents the gold standard treatment for major BDIs and is ideally performed during the immediate postoperative period (within 72 h)
    - Tension-free bilioenteric anastomosis with good mucosal apposition and vascularized ducts
  - Late repair -> Considered after the resolution of acute or subacute situations and the closure of a biliary fistula on dilated bile ducts

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Research Article

Early or Delayed Intervention for Bile Duct Injuries following Laparoscopic Cholecystectomy? A Dilemma Looking for an Answer

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- Gastroenterology Research and Practice, 2015
- Retrospective review BDI cases from 1991 – 2011
  - Early repair : within 2 weeks after injury
  - Late repair : > 12 weeks after injury
- Compare postop morbidity

Table 1: Patients and BDI characteristics.

Age	
Mean (range)	53 (33–83)
Gender, *n* (%)	
Male	42 (45.7)
Female	50 (54.3)
LC performed to, *n* (%)	
Our unit	21 (22.8)
Other units	71 (77.2)
Presenting symptoms, *n* (%)	
Diagnosis during LC	22 (23.9)
Bile leak	20 (21.7)
Biloma	13 (14.1)
Biliary peritonitis	5 (5.5)
Cholangitis	11 (12)
Obstructive jaundice	21 (22.8)
Type of injury according to Strasberg classification, *n* (%)	
Type A	**7 (7.6)**
Type B	**0 (0)**
Type C	**4 (4.3)**
Type D	**18 (19.6)**
Type E	**63 (68.5)**
E1	10 (10.9)
E2	26 (28.3)
E3	22 (23.9)
E4	4 (4.3)
E5	1 (1.1)

Table 2: Definite management of BDI according to their type.

Strasberg classification of bile duct injuries ($n = 92$)			Management					
Type	Description	Number of patients (%)	Conservative (wait and see)	Drainage	PTC	ERCP	Bile duct repair	Reconstruction
Type A	Bile leak from cystic duct stump or the gallbladder bed	7	2	1	1	3	0	0
Type B	Right segmental duct division where both ends are clipped	0	0	0	0	0	0	0
Type C	Right segmental duct division where the hepatic end remains open	4	1	1	2	0	0	0
Type D	Lateral wall injury to the common bile duct	18	0	0	3	4	7	4
Type E	Major CBD division/stricture with 5 subdivisions	**63**	**0**	**0**	**0**	**0**	**9**	**54**
E1	Site of CBD division is >2 cm from the bifurcation	10	0	0	0	0	4	6
E2	Site of CBD division is <2 cm from the bifurcation	26	0	0	0	0	3	23
E3	Site of CBD division is at the bifurcation	22	0	0	0	0	2	20
E4	Division or injury to the left, right, or both hepatic ducts	4	0	0	0	0	0	4
E5	An injury of a right segmental duct along with a type E3/E4 injury	1	0	0	0	0	0	1
Total		92	3	2	6	7	16	58

Table 3: Surgical management of bile duct injuries ($n = 67$).

	Total		Bile duct repair		Reconstruction	
	Patients operated on by HBS (%)	Patients operated on by non-HBS (%)	Patients operated on by HBS (%)	Patients operated on by non-HBS (%)	Patients operated on by HBS (%)	Patients operated on by non-HBS (%)
Early (<2 weeks) repair or reconstruction	32 (57.1)	7 (38.9)	3 (100)	6 (46.2)	29 (54.7)	1 (20)
Intermediate (2–12 weeks) repair or reconstruction	0 (0)	11 (61.1)	0 (0)	7 (53.8)	0 (0)	4 (80)
Late (>12 weeks) repair or reconstruction	24 (42.9)	0 (0)	0 (0)	0 (0)	24 (45.3)	0 (0)
Total	56 (100)	18 (100)	3 (100)	13 (100)	53 (100)	5 (100)

HBS: specialized hepatobiliary surgeons.
Non-HBS: nonspecialized hepatobiliary surgeons.

Table 4: Summary of long-term outcomes after surgical intervention to BDI; results by surgeon group.

	Non-HBS (18)	HBS (56)	Total (74)	Significance
Stricture, number (%)	11 (61.1)	11 (19.6%)	22 (29.7)	**0.001**
Recurrent cholangitis, number (%)	4 (22.2)	7 (12.5%)	11 (14.9)	0.445
Intervention/dilation, number (%)	10 (55.6)	11 (19.6%)	21 (28.4)	**0.003**
Redo reconstruction, number (%)	5 (27.8)	0 (0%)	5 (6.8)	**0.001**
Overall long-term morbidity, number (%)	15 (83.3)	15 (26.8%)	30 (40.5)	<**0.001**

- Comparing repair of BDI by non-HPB surgeon vs HPB surgeon
  - Less complication in HPB experienced surgery

TABLE 5: Results of biliary reconstruction by HBS.

	Early (<2 weeks) repair or reconstruction (34)	Late (>12 weeks) repair or reconstruction (22)	Significance	Total (56)
Immediate postoperative complications				
Wound infection, number (%)	5 (14.7)	6 (27.3)	0.310	11 (19.6)
Bile leak, number (%)	4 (11.8)	3 (13.6)	0.999	7 (12.5)
Biloma, number (%)	3 (8.8)	2 (9.1)	0.999	5 (8.9)
Biliary peritonitis, number (%)	0 (0)	1 (4.5)	0.393	1 (1.8)
Overall immediate morbidity, number (%)	7 (20.6)	6 (27.3)	0.563	13 (23.2)
Long-term postoperative complications				
Stricture, number (%)	6 (17.6)	5 (22.72)	0.736	11 (19.6)
Recurrent cholangitis, number (%)	4 (11.8)	3 (13.6)	0.999	7 (12.5)
Intervention/dilation, number (%)	6 (17.6)	5 (22.72)	0.736	11 (19.6)
Redo reconstruction, number (%)	0 (0)	0 (0)	*	0 (0)
Overall long-term morbidity, number (%)	8 (23.5)	7 (31.8)	0.494	15 (26.8)
Mortality, number (%)	1 (2.9)	1 (4.5)	0.999	2 (3.6)

*No statistics are computed because the absence of need of redo reconstruction is a constant.

- Early(<2 weeks) and Late(>12 weeks) repair have similar overall immediate and long-term postoperative complications

Systematic review

BJS Open
Open Access

Optimal timing for surgical reconstruction of bile duct injury: meta-analysis

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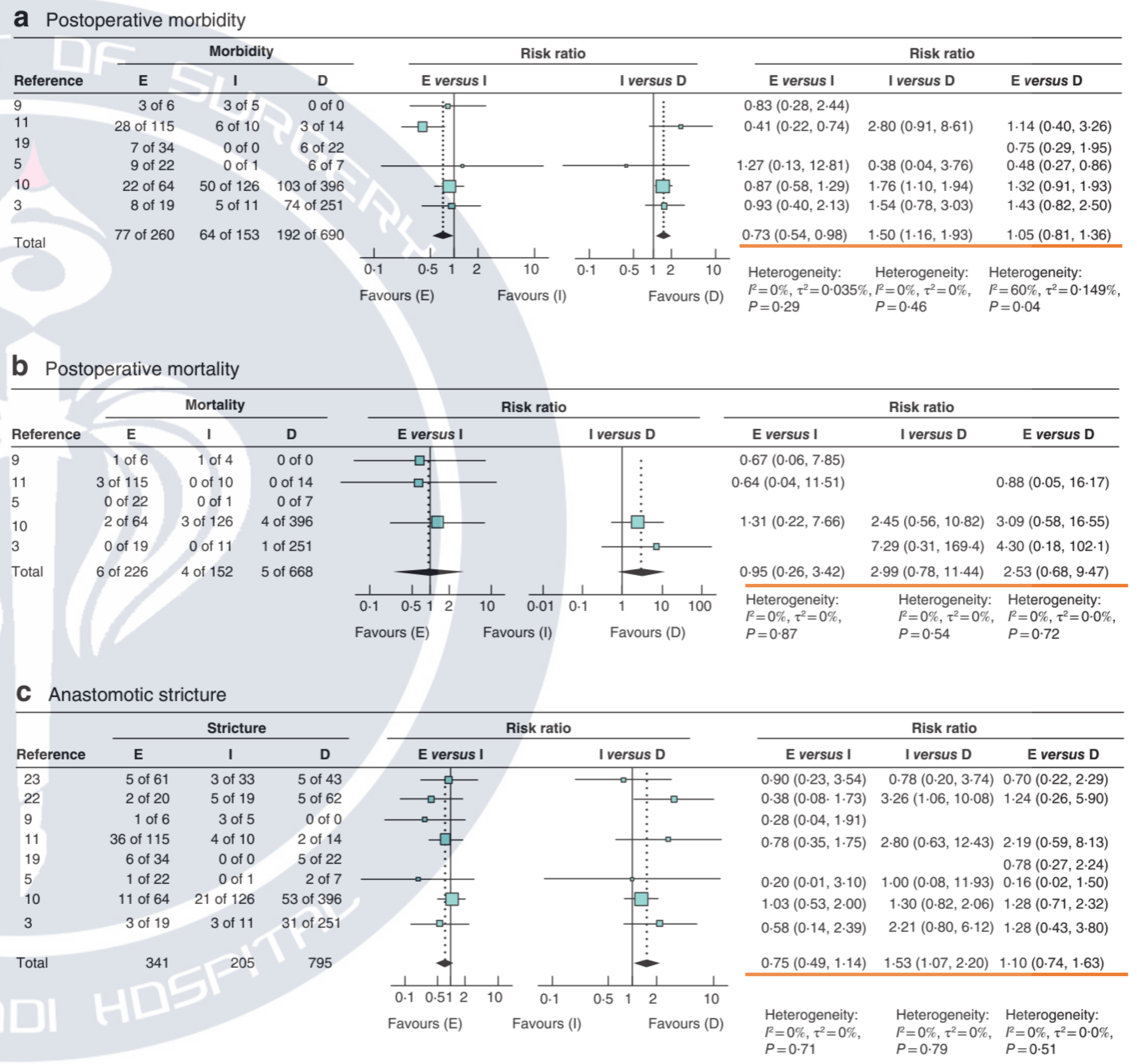
- BJS Open 2020
- Systematic review and meta-analysis
  - Evaluating timing of HJ for BDI
    - Postop morbidity
    - Anastomotic stricture
  - 21 retrospective studies
- Time interval
  - Early : < 14 days
  - Intermediate : 2-6 weeks
  - Delayed : > 6 weeks
- Postop morbidity was lower in early and delayed comparing to intermediate period

CBD injury: Sukhum Kobdej,MD.(F)

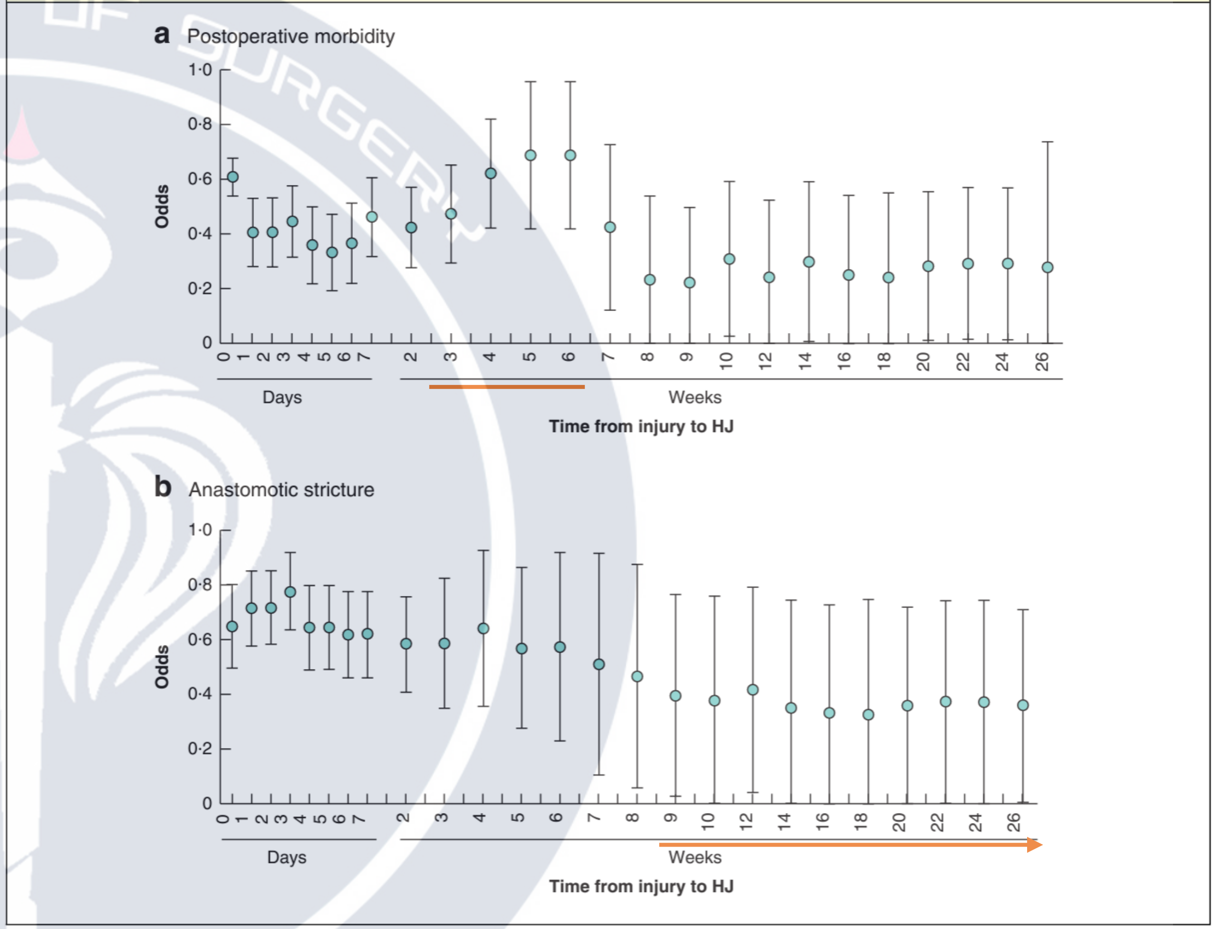
Fig. 3 Forest plots comparing risk ratios for early (less than 14 days), intermediate (14–42 days) and delayed (more than 42 days) reconstruction of bile duct injury



a Postoperative morbidity; **b** postoperative mortality; **c** anastomotic stricture. An inverse-variance random-effects model was used for meta-analysis. Risk ratios are shown with 95 per cent confidence intervals. E, early reconstruction; I, intermediate reconstruction; D, delayed reconstruction.

- Postoperative morbidity was lower in early and delayed group
  - Odds of postop morbidity was increased in 3-6 weeks
- Anastomotic stricture
  - Early vs intermediate : no significant different rate of anastomotic stricture
  - Odds gradually decreased with longer time interval: > 9 weeks

Fig. 4 Estimated odds for the association between time from injury to repair and postoperative morbidity and anastomotic stricture



a Postoperative morbidity; **b** anastomotic stricture. Mean odds with 95 per cent c.i. values are shown. HJ, hepaticojejunostomy.

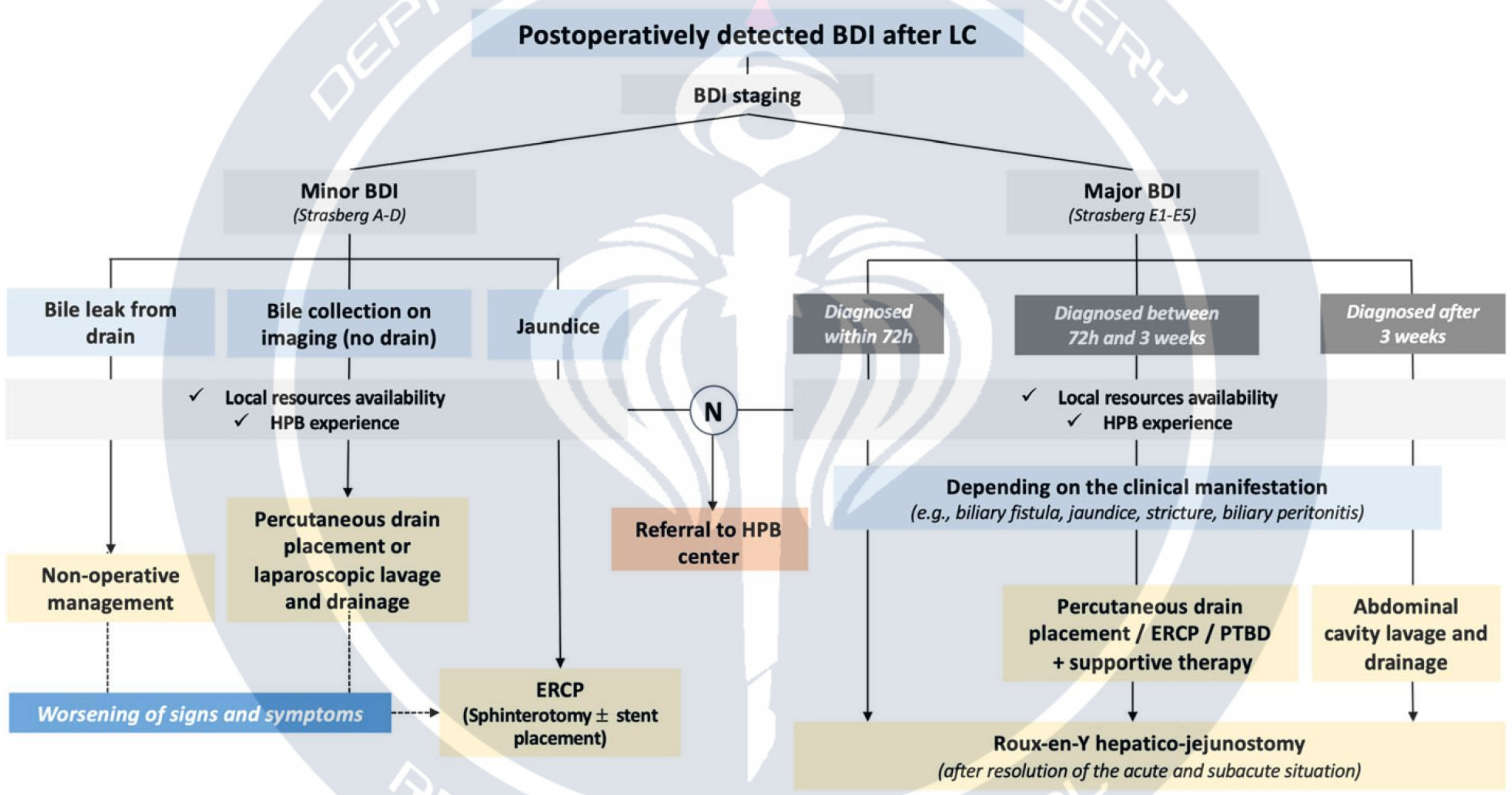


Fig. 2 Decisional tree in case of post-operatively detected BDI. *N stands for no*

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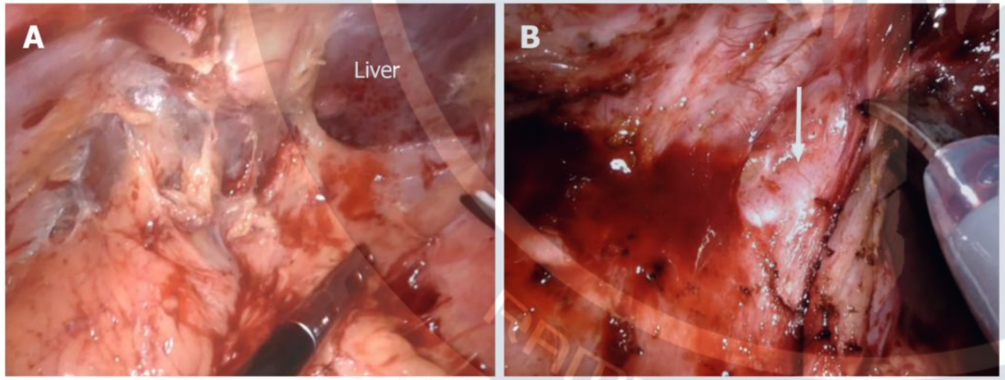
Minimally invasive management

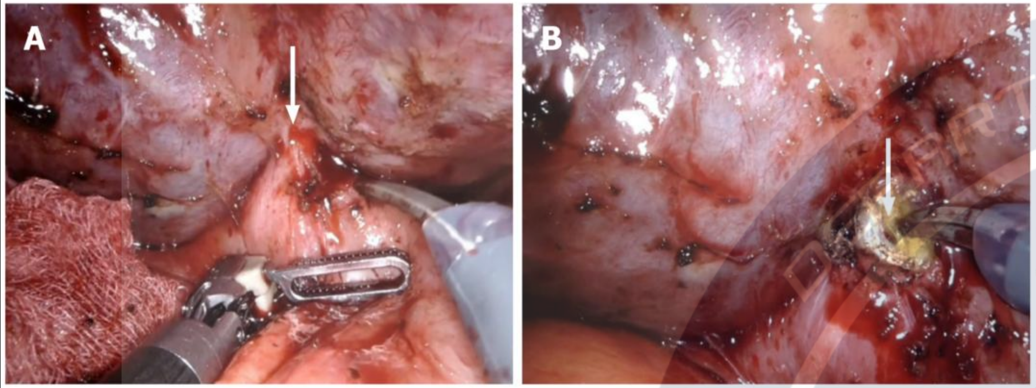
- Laparoscopic/Robotic repair of postcholecystectomy biliary stricture
- Robotic repair of biliary strictures
  - Advantages over the laparoscopic approach in terms of magnification, stable vision, and a greater degree of freedom of movement with ease of intracorporeal suturing



DOI: 10.4240/wjgs.v15.i10.2098 **Copyright** ©The Author(s) 2023.

Figure 1 Adhesiolysis and initial dissection phase. A: Perihepatic adhesions are left undisturbed to facilitate liver retraction and exposure of the hilum; B: Dissection proceeds towards the umbilical fissure with careful identification and preservation of the left hepatic artery (arrow).

Kalayarasan R et al. Minimally invasive surgery for biliary stricture. World J Gastrointest Surg 2023 October 27; 15(10): 2098-2107



DOI: 10.4240/wjgs.v15.i10.2098

Figure 2 Identification of hepatic duct. A: Internal fistula between the hepatic duct and duodenum (arrow); B: Division of the fistula facilitates visualization of the hepatic duct (arrow).

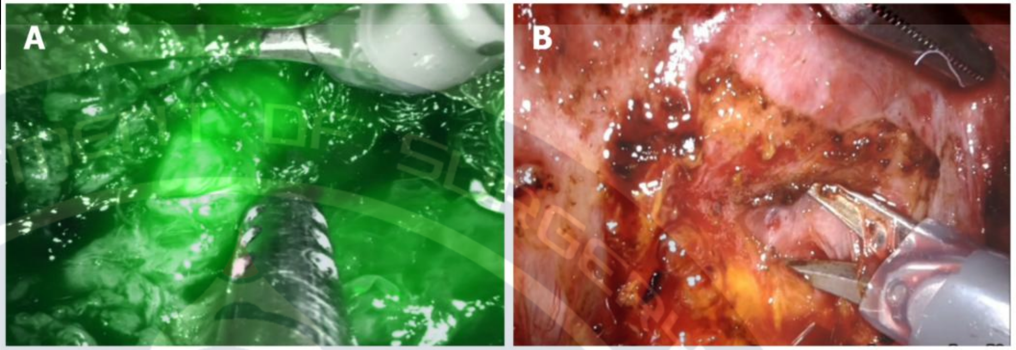


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Figure 3 Lowering the hilar plate. A: Indocyanine green fluorescence facilitates hepatic duct identification; B: Hilar plate lowered by dissection between the Glissonean sheath and Laennec's capsule.

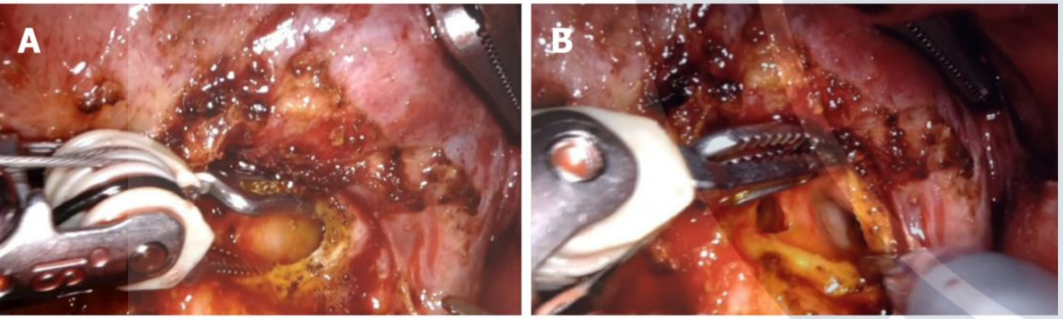

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Figure 4 Opening the hepatic duct. A: Identification and opening of the left hepatic duct; B: Confluence of left hepatic duct with right hepatic duct identified.

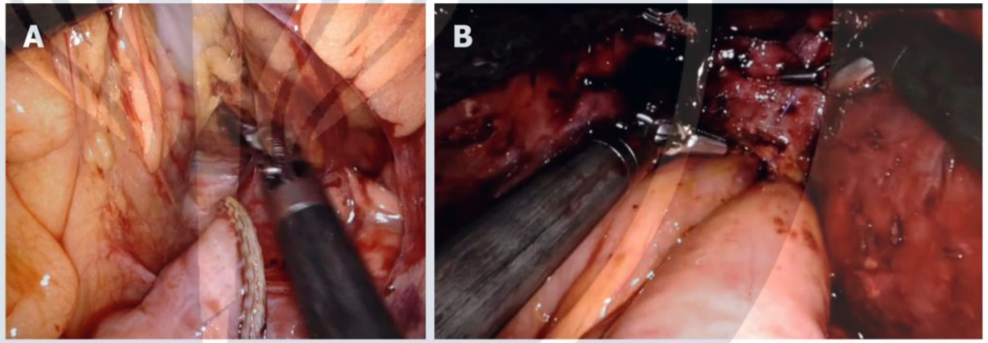

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Figure 5 Roux-en-Y hepaticojejunostomy. A: Roux limb of jejunum taken to the supracolic compartment through the mesocolic window; B: Completed hepaticojejunostomy.

Kalayarasan R et al. Minimally invasive surgery for biliary stricture. World J Gastrointest Surg 2023 October 27; 15(10): 2098-2107

Table 1 Studies on laparoscopic repair of postcholecystectomy biliary stricture

Ref.	Year	Patients	Strasberg injury type	Method of reconstruction	Mean operative time (min)	Blood loss (mL)	Conversion to open	Overall morbidity	Specific biliary complications	Length of stay (d)	Follow up
Cuendis-Velázquez *et al* [7]	2016	29	C, E1-E4	HJ	240	200	1	31.03	Bile leak–5 patients. One patient required laparotomy and drainage of bile collection	8	36 (range 7-36) mon, Anastomotic patency rate 96.6%
Gomez *et al*[9]	2020	20	E1-E4	HJ	146.5	15-50	None	10%	One patient had bile leak and was managed conservatively	4.5 (mean)	5 yr–no long-term complications
Sahoo *et al*[8]	2021	16		HJ	280	176	None	12.5%	Two patients had bile leak and were managed conservatively	8.5	28 mo
Javed *et al*[10]	2021	29	E1-E5	HJ-13 patients, HD-16 patients	210	50	None	20%	Four patients had bile leak and were managed conservatively	6	9 mo–one patient had anastomotic strictest and managed with repeater dilations

Table 2 Studies on robotic repair of postcholecystectomy biliary stricture

Ref.	Year	Patients	Strasberg injury type	Method of reconstruction	Operative time (min)	Blood loss (mL)	Overall morbidity	Length of stay (d)	Specific complications	Follow up
Giulianotti *et al*[11]	2018	14	E1-E5	HJ-12 patients, Kasai procedure-2 patients	280.6	135	28.6%	8.4	Bile leak-two patients and 1 patient required pigtail catheter insertion. Subhepatic abscess-one patient	36.1 mo, 2 patients had mild HJ stenosis and cholangitis. Managed by PTBD and multiple transhepatic dilatations
Marino *et al* [12]	2019	12	E1-E4	HJ	260	252	16.7%	9.4	1 patient developed subhepatic abscess and required pigtail catheter insertion	12 mo–1 patient had anastomotic stenosis and revision robotic HJ was done
Sucandyet al [13]	2021	8		HJ	259	50	14%	8	None	22 mo–1 patient had anastomotic stenosis at 10 mo and required transhepatic dilatation

HJ: Hepaticojejunostomy; PTBD: Percutaneous transhepatic biliary drainage.

Kalayarasan R et al. Minimally invasive surgery for biliary stricture. World J Gastrointest Surg 2023 October 27; 15(10): 2098-2107

ORIGINAL ARTICLE: Clinical Endoscopy

Gastrointestinal Endoscopy 2024

Magnetic compression anastomosis for the treatment of complete biliary obstruction after cholecystectomy

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Seung-Moon Joo, MD,[3] Kwang-Hun Lee, MD, PhD,[4] Moon Jae Chung, MD, PhD,[5] Dong Ki Lee, MD, PhD[1]

Seoul, South Korea

TABLE 1. Patient characteristics (N = 10)

Characteristic	Value
Age, y	50.9 ± 19.1
Sex	
Male	5
Female	5
Diagnosis for operation	
Acute cholecystitis	9 (90)
Gallbladder cancer	1 (10)
Type of surgery	
Open cholecystectomy	5 (50)
Laparoscopic cholecystectomy	5 (50)
Strasberg classification	
Type B	2 (25)
Type C	3 (25)
Type E	5 (50)
Duration between operation and stricture diagnosis, mo	3.9 ± 4.2

Values are mean ± standard deviation or n (%) unless otherwise indicated.

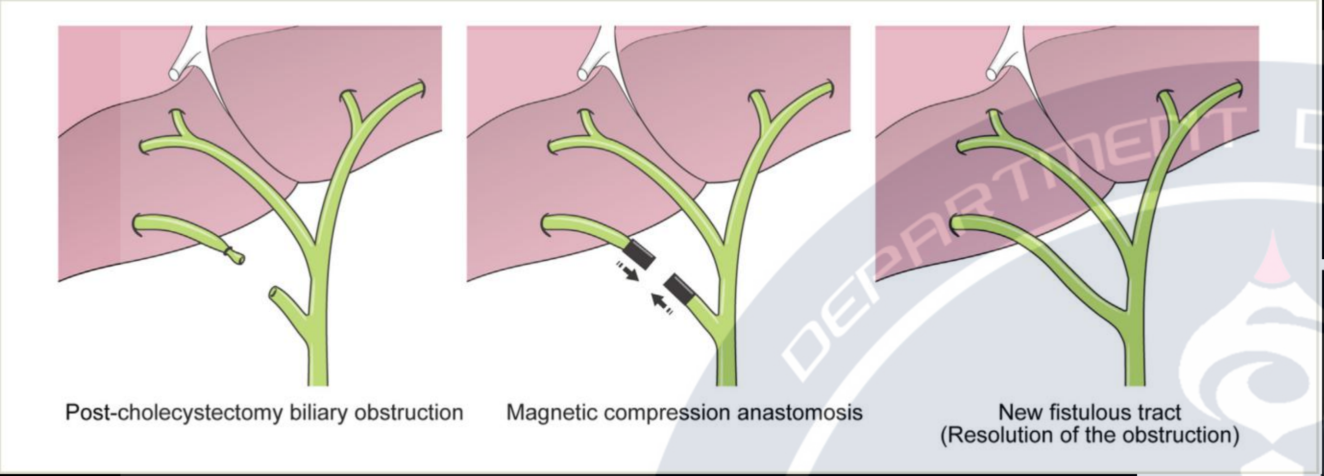
TABLE 2. Clinical outcomes for the 10 study patients

Outcome	Value
FCSEMS indwelling period and number of exchanges	
Total indwelling period, mo	5.4 ± 2.3
Indwelling period per FCSEMS, mo	2.6 ± .7
No. of exchanges, 0/1/2/3	2/4/2/2
Total follow-up duration after stent removal, mo	50.2 ± 38.1
Recurrence-free duration, mo	32.5 ± 29.4
Stricture recurrence	2 (22.2)
Strasberg type E	2
Adverse events	0

Values are mean ± standard deviation or n (%) unless otherwise indicated.
FCSEMS, Fully covered self-expandable metallic stent.

- 10 patients
  - Successful recanalization in all 10 patients
  - Partial restenosis in 2 patients

GRAPHICAL ABSTRACT



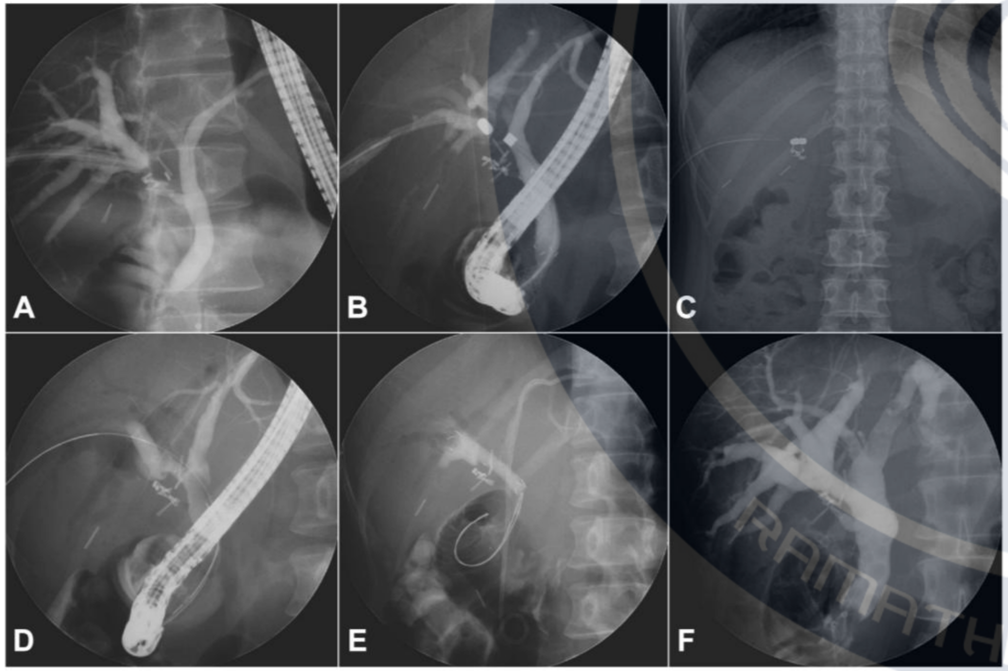


Figure 1. Magnetic compression anastomosis for post-cholecystectomy complete obstruction (Strasberg type B). **A,** A cholangiogram showed complete obstruction of the right intrahepatic duct after cholecystectomy. **B,** One magnet was delivered through the percutaneous transhepatic biliary drainage tract, and the other was advanced through the common bile duct. **C,** Magnets were approximated via 2 delivery tracts. **D,** After the approximated magnets were removed, the guidewire could pass the stricture site. **E,** A fully covered self-expandable metal stent was inserted at the recanalized site. **F,** After removal of the fully covered self-expandable metal stent, a cholangiogram showed complete resolution of the biliary obstruction.

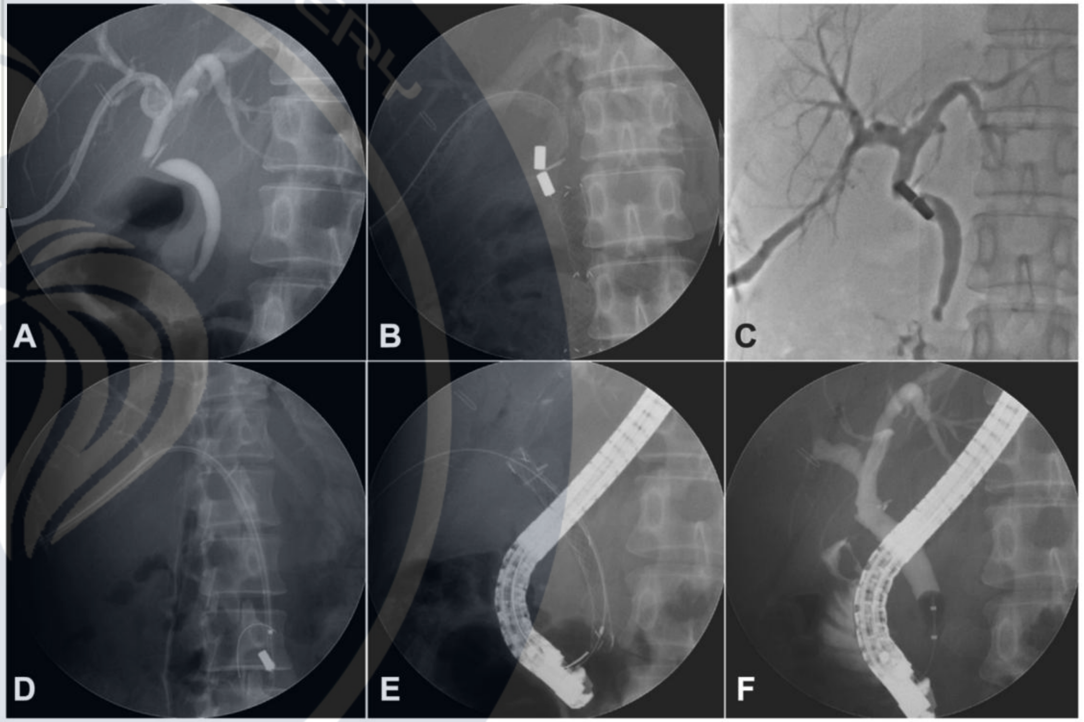


Figure 3. Magnetic compression anastomosis for a post-cholecystectomy complete obstruction (Strasberg type E). **A,** A cholangiogram showed complete obstruction of the common hepatic duct after cholecystectomy. **B,** One magnet was delivered through the percutaneous transhepatic biliary drainage tract, and the other was advanced through the common bile duct. **C,** Magnets were approximated via 2 delivery tracts. **D,** After the approximated magnets were removed, the guidewire could pass the stricture site. **E,** A fully covered self-expandable metal stent was inserted at the recanalized site and exchanged 3 times over 7 months. **F,** After removal of the fully covered self-expandable metal stent, a cholangiogram showed complete resolution of the biliary obstruction.

Surgical Management

- Incision and exposure : Rt subcostal +/- midline extension or upper midline
- Lysis adhesion : Typically significant adhesion around the injured bile duct
  - Completely mobilize and free up the quadrate lobe(IVb)
- Removal of visualized clips
  - Bile ducts are confirmed by needle aspiration
  - Cholangiogram of the ducts proximal to the injury : To visualize all segments of the liver and identify aberrant bile duct anatomy
- Kocher maneuver : Facilitate exposure of the distal common bile duct stump which will be closed utilizing a continuous running permanent suture

Seeras K, Qasawa RN, Kashyap S, et al. Bile Duct Repair. [Updated 2023 May 22]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan

Surgical Management

- Exposure of the left hepatic duct (LHD)
  - The hilar plate (extension of Glisson's capsule from the liver onto the hepatic ducts) is incised anteriorly to the LHD thus lowering and facilitating exposure of the duct
- Exposure of the right hepatic duct (RHD)
  - Incise Glisson's capsule at the base of segment IVb -> exposing the confluence of the right and left hepatic ducts
  - Continuing the plane already created when the LHD was exposed toward segment V exposing the right anterior and posterior sectoral ducts
  - Previously placed percutaneous transhepatic biliary drainage can help identifying right ductal anatomy

Seeras K, Qasawa RN, Kashyap S, et al. Bile Duct Repair. [Updated 2023 May 22]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan

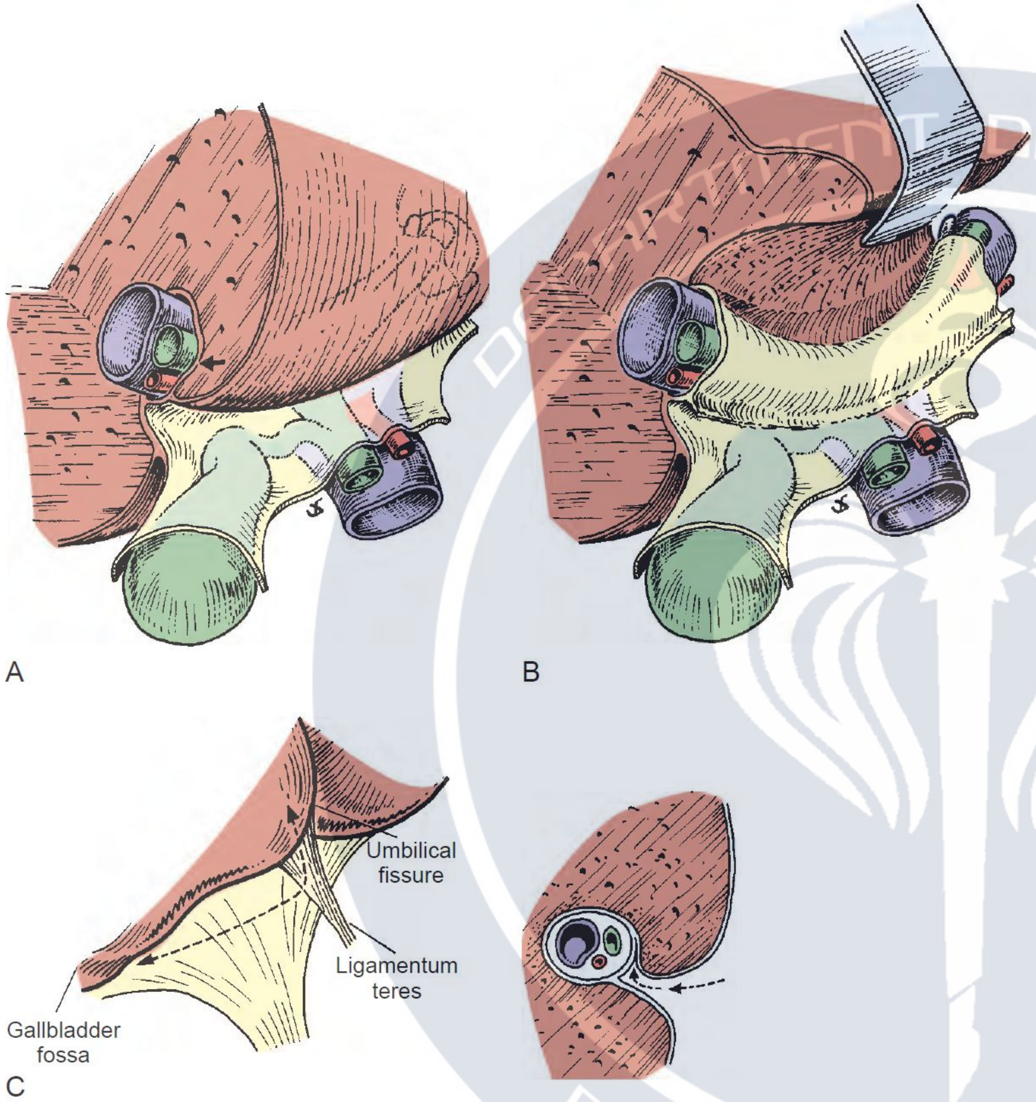


FIGURE 2.20 **A,** Relationship between the posterior aspect of segment IV and the biliary confluence. The hilar plate *(arrow)* is formed by the fusion of the connective tissue enclosing the biliary and vascular elements with the Glisson capsule. **B,** Biliary confluence and left hepatic duct exposed by lifting segment IV upward after incision of the Glisson capsule at its base. This technique, *lowering of the hilar plate*, generally is used to display a dilated bile duct above an iatrogenic stricture or hilar cholangiocarcinoma. **C,** Line of incision *(left)* to allow extensive mobilization of segment IV. This maneuver is of particular value for high bile duct strictures and in the presence of liver atrophy or hypertrophy. The procedure consists of lifting segment IV upward (**A** and **B**), then not only opening the umbilical fissure but also incising the deepest portion of the gallbladder fossa. *Right*, Incision of the Glisson capsule to gain access to the biliary system *(arrow)*. (**B,** From Hepp J, Couinaud C. L'abord et l'utilisation du canal hépatique gauche dans les réparations de la voie biliare principale. *Presse Med*. 1956;64:947–948.)

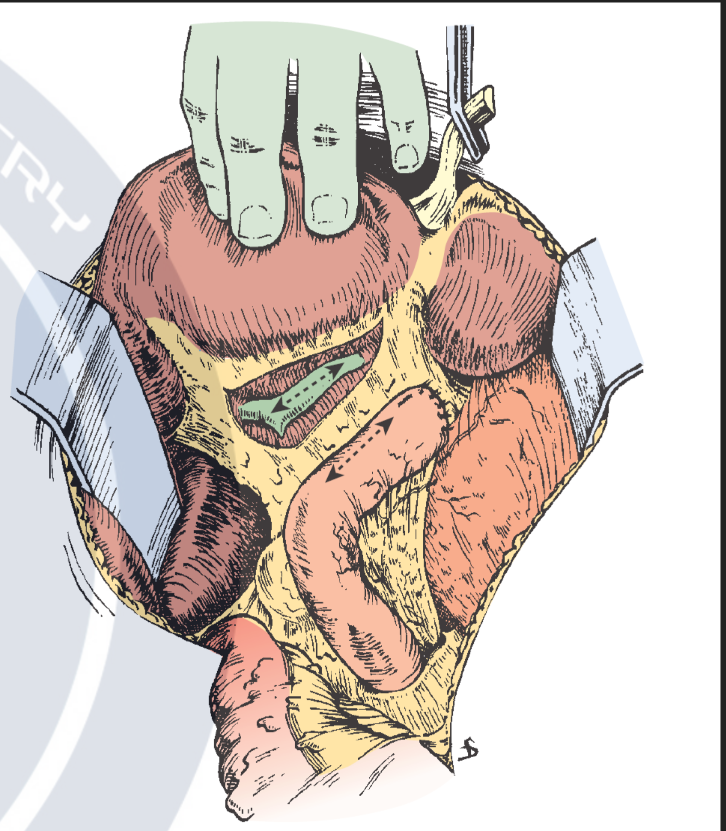


FIGURE 32.6 **The hilar plate is lowered, and the left hepatic duct is exposed for dissection.** The exposure is carried medially and to the right to expose the confluence and the right hepatic duct.

BLUMGART'S Surgery *of the* Liver, Biliary Tract and Pancreas. 7th ed. 2023

Surgical Management

- Preparation of bile duct for anastomosis
  - Depending on the classification of injury and its proximity to the hilar plate, the repair technique is chosen
  - E1 : Remaining common duct may be debrided and used for the hepaticojejunostomy
  - E2-E3 (no separation of RHD and LHD) : Hepp-Couinaud approach can be used
    - Incising the LHD horizontally with extension and sometimes across the confluence to the RHD in preparation for a hepaticojejunostomy
  - E5 lesions will typically require two separate end-to-side anastomoses of both the aberrant right hepatic duct and the main hepatic duct to the jejunum
  - For injuries that completely separate the right and left biliary systems
    - Separate right and left biliary-enteric anastomoses are performed
    - If the 2 ducts are within 1 cm of each other, they can be approximated to form one common channel

Seeras K, Qasawa RN, Kashyap S, et al. Bile Duct Repair. [Updated 2023 May 22]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan

Surgical Management

- Stenting of the HJ anastomosis is controversial
  - There has been weak evidence that it prevents HJ anastomotic leaks or strictures and is selectively used according to surgeon preference
    - Already present PTC biliary stent can be passed from the proximal bile ducts through the anastomosis into the jejunum
    - Silastic stent through the anastomosis into the proximal bile ducts and then bringing it anteriorly through the hepatic parenchyma
    - T tube through the anterior wall of the bile duct and having one limb traversing the HJ anastomosis
- The cornerstone of the technique is to achieve a tension-free anastomosis

Seeras K, Qasawa RN, Kashyap S, et al. Bile Duct Repair. [Updated 2023 May 22]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan

End-to-end ductal anastomosis in biliary reconstruction: indications and limitations

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- Can J Surg, Vol. 57, No. 4, August 2014
- End-to-end anastomosis is less performed due to high risk of biliary stricture compared to HJ anastomosis (upto 80%)
- Should be considered in selected patients
  - Not recommend in high grade injury (E3, E4), vasculobiliary injury
- Anastomotic edge should be healthy: no inflammation, ischemia
- Anastomosis should be tension free and well-vascularized
- Technique
  - Dissection of proximal and distal stumps as far as the tissues are healthy
    - Careful dissection to save intact axial vessels
  - Maximal length loss 4 cm
    - Wide kocherization can facilitate approximation

- T tube insertion
  - Use and duration of biliary drainage is controversial
  - Benefit : limitation of inflammation and fibrosis occurring after surgery
    - Some study showed prevention of anastomotic stricture
  - Disadvantage : higher risk of postop complications
    - Biliary fistula

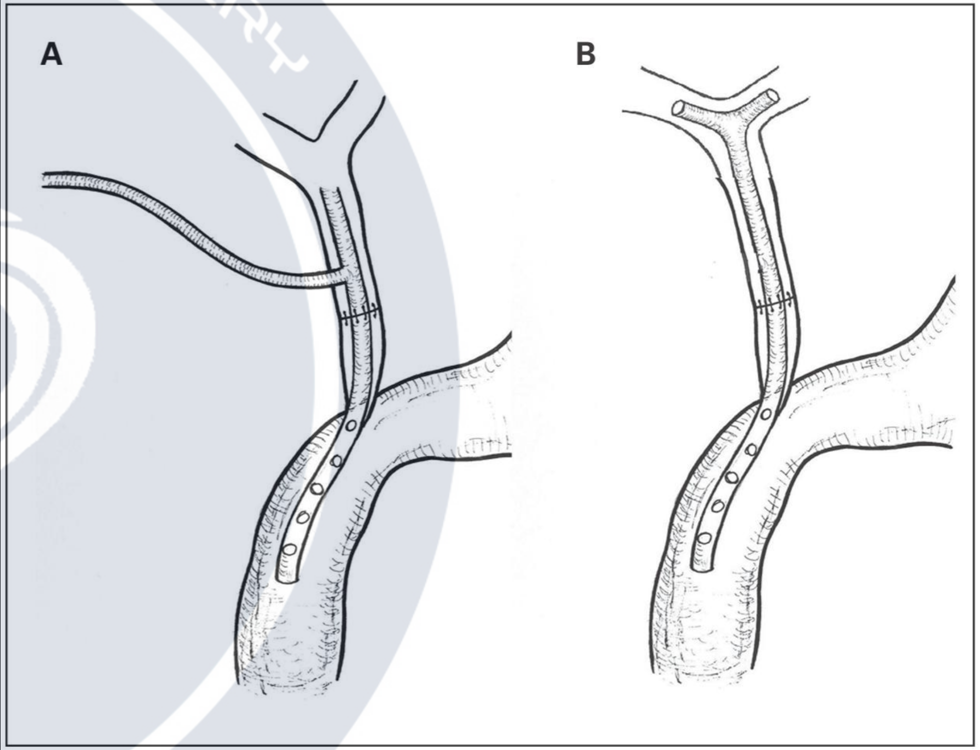


Fig. 1: Types of biliary drainage using T-tube. **(A)** External T-drainage. **(B)** Internal Y-drainage.

J Gastrointest Surg (2007) 11:296–302
DOI 10.1007/s11605-007-0087-1

Long-term Results of a Primary End-to-end Anastomosis in Peroperative Detected Bile Duct Injury

P. R. de Reuver · O. R. C. Busch · E. A. Rauws ·
J. S. Lameris · Th. M. van Gulik · D. J. Gouma

Published online: 24 February 2007

- Retrospective review BDI patients referred to this center after complicated end-to-end anastomosis from 1991-2006

Table 1 Patient Characteristics

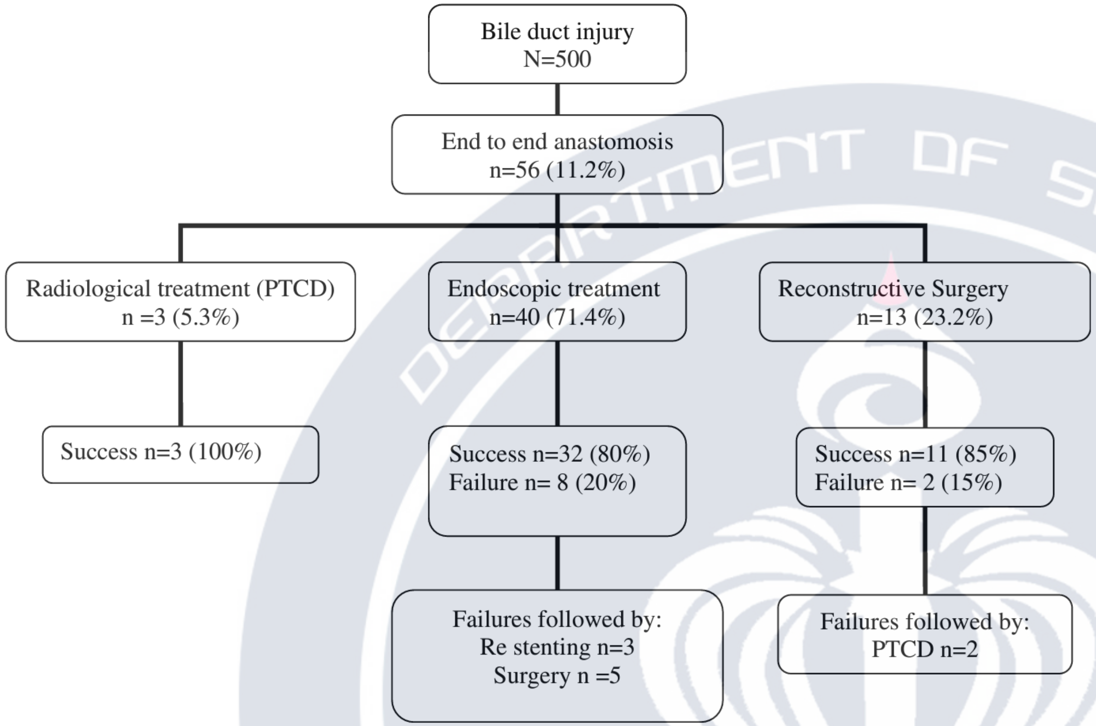
	Primary EEA	
	n=56	%
Age at cholecystectomy		
Mean (years)	52	
Gender		
Female	43	77
Indication for cholecystectomy		
Symptomatic cholelithiasis	45	80
Cholecystitis	5	9
Cholecystitis a froid	6	1
Type of initial operation		
Open procedure	8	14
Laparoscopic to open procedure	48	86
Anastomosis over T-tube	49	88
Duration of T-tube in situ		
Days, median (range)	42(2–145)	

Table 2 Referral Pattern

	Primary EEA	
	n=56	%
Time interval between injury and referral		
Weeks, median (range)	16 (0–141)	
Intervention after EEA and before referral		
Explorative relaparotomy	2	4
Percutaneous drainage	5	9
Endoscopic stenting	12	21
Endoscopic papillotomy	9	16
PTD[a]	2	4
Symptoms at referral		
Cholestasis	14	25
Cholangitis/fever	10	18
Abdominal pain	15	27
Abces/biloma	4	7
Uncontrolled sepsis/peritonitis	3	5
Diagnosis at referral		
Stenosis	38	68
Leakage	10	18
Combination of stenosis and leakage	8	14
Location of injury at referral[b]		
I	9	16
II	21	38
III	17	30
IV	7	12
V	2	4

[a] Percutaneous transhepatic drainage
[b] According to Bismuth classification

Figure 3 Flow diagram of the success and failure rates after a multidisciplinary treatment of patients who underwent a peroperative end to end anastomosis for bile duct injury. Given percentages are calculated from the number of patients in the previous flow box. *PTCD* Percutaneous transhepatic catheter dilatation.



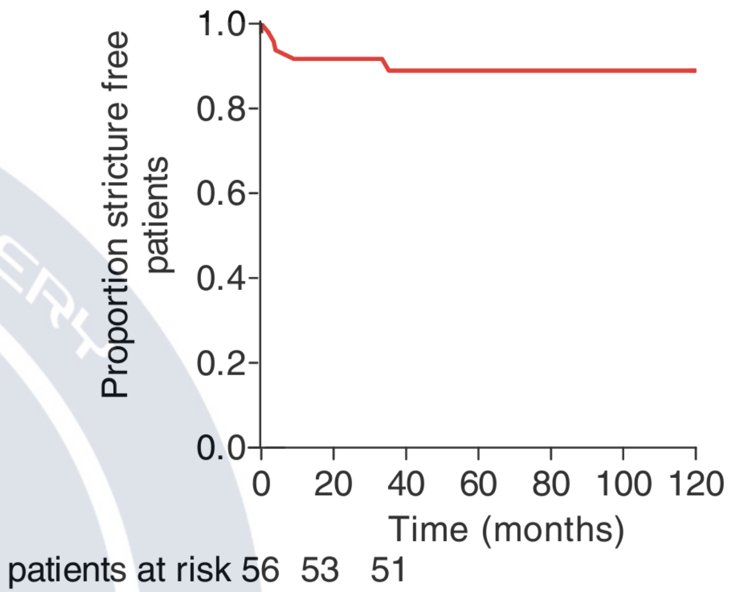


Figure 4 Kaplan–Meier plot showing proportion of patients without restenosis among 56 bile duct injury patients treated for complications after EEA.

Overall 5-yr stricture free survival in total cohort 91%

- Mean follow-up of 7.1 years -> restenosis after treatment developed in 9% of the patients
  - Endoscopic therapy : Restenosis occurred a relatively short time after stent removal (within 2 to 8 months follow-up)
  - Endoscopic treatment is not associated with a high rate of long-term restenosis after stent removal
- EEA could be a sufficient treatment in non extensive tissue loss BDI
  - Postop complications(stricture or leakage) can be managed by multidisciplinary team

OPERATIVE TECHNIQUE

SECTION EDITOR: JACK PICKLEMAN, MD

Biliary Duct Injury

Partial Segment IV Resection for Intrahepatic Reconstruction of Biliary Lesions

Miguel Angel Mercado, MD; Héctor Orozco, MD; Lorenzo de la Garza, MD; Luz María López-Martínez, MD; Alan Contreras, MD; Erika Guillén-Navarro, MD

- Arch Surg. 1999; 134: 1008-1010
- Technique
  - Adhesiolysis
  - Remove the scar tissue and identify bile duct
  - For very high injury : usually no adequate ducts
  - Remove base of segment 4 to obtain antero-posterior view of the duct
    - Incision hepatic capsule 3 cm deep and in oblique fashion
    - Lt duct can be clearly visible and Rt duct can be identified
  - Transhepatic T-tube stent -> postop flush 3 times a week
- 36 mo mean follow up
  - 20/22 -> good QoL
  - 2/22 -> still have stent in place

Characteristic	No. of Patients
Male-female ratio	16:6
Type of injury	
Bismuth IV	22
Strasberg E3 and E4	22
Transhepatic T tube	22
Previous operation (attempt at repair)	19
Individual left and right hepatojejunal anastomosis	19
Hepatojejunal anastomosis (junction preserved)	3
Restenosis	2
Good quality of life	20

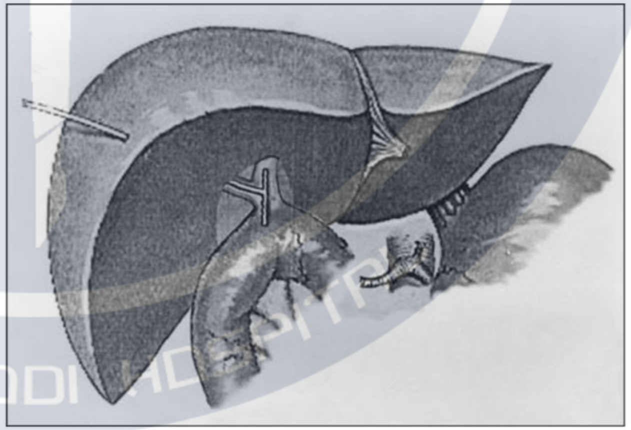


Figure 1. *Transhepatic T tube in place for stenting of both ducts. Biliary junction is preserved.*

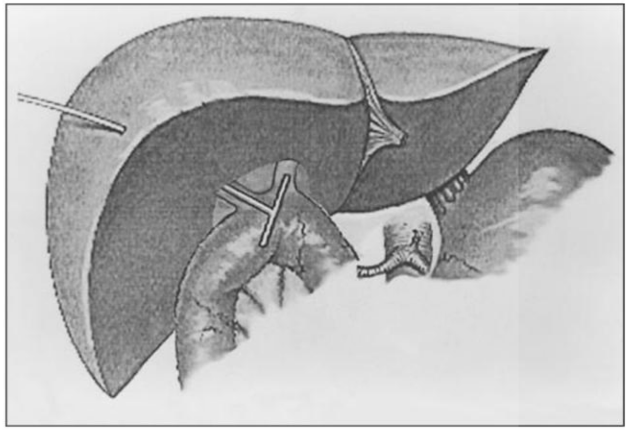


Figure 2. *Transhepatic T tube in place for stenting of both ducts without preserved biliary junction. After performing the right anastomosis, the short limb of the T tube is pulled out through a new opening in the jejunum to stent the left anastomosis.*

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DOI: 10.1002/ags3.12500

HOW I DO IT

AGSurg Annals of Gastroenterological Surgery Open Access
WILEY

Total Hilar Exposure Maneuver for Repair of Complex Bile Duct Injury

Nan-ak Wiboonkhwan | Thakerng Pitakteerabundit | Tortrakoon Thongkan

- 6 cases of complex BDI performing repair by total hilar exposure maneuver
  - E3 : 3 cases
  - E4 : 3 cases
- Median follow up 12 mo

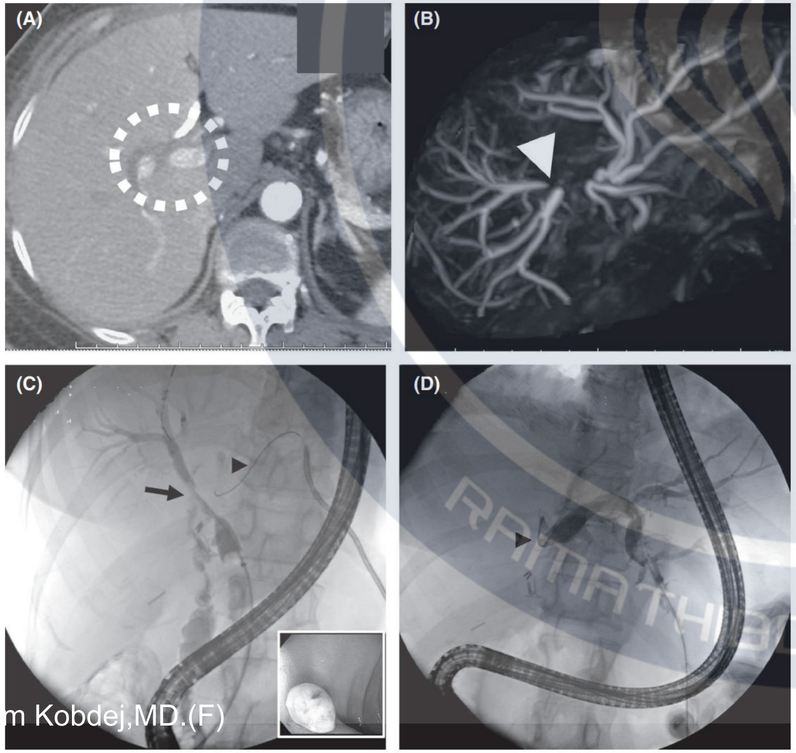
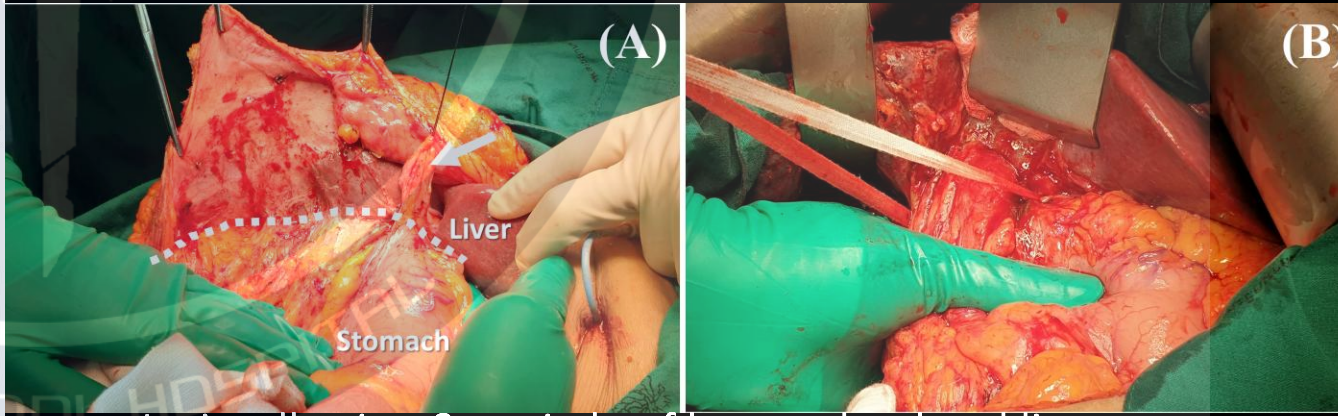


FIGURE 1 Preoperative imaging evaluation. (A) Computed tomography of the liver showed injury to the right hepatic artery (circle) with distal reconstitution. (B) Magnetic resonance cholangiography showed E4 injury with noncommunication of the right anterior and posterior ducts (white arrow). (C) Endoscopic retrograde cholangiography with percutaneous cholangiography (PTC) revealed a bilioenteric fistula extending to the duodenum (black arrow) and a wire in the left hepatic duct (LHD) (arrowhead). (D) PTC showed noncommunication of the LHD (arrowhead) with the right hepatic duct and an E4 injury

m Kobdej,MD.(F)



Lysis adhesion & encircle of hepatoduodenal ligament

1. Identify landmarks
   - Umbilical fissure
   - Base of segment 4b
   - Cystic-hilar plate
   - Rt anterior pedicle(RAP)

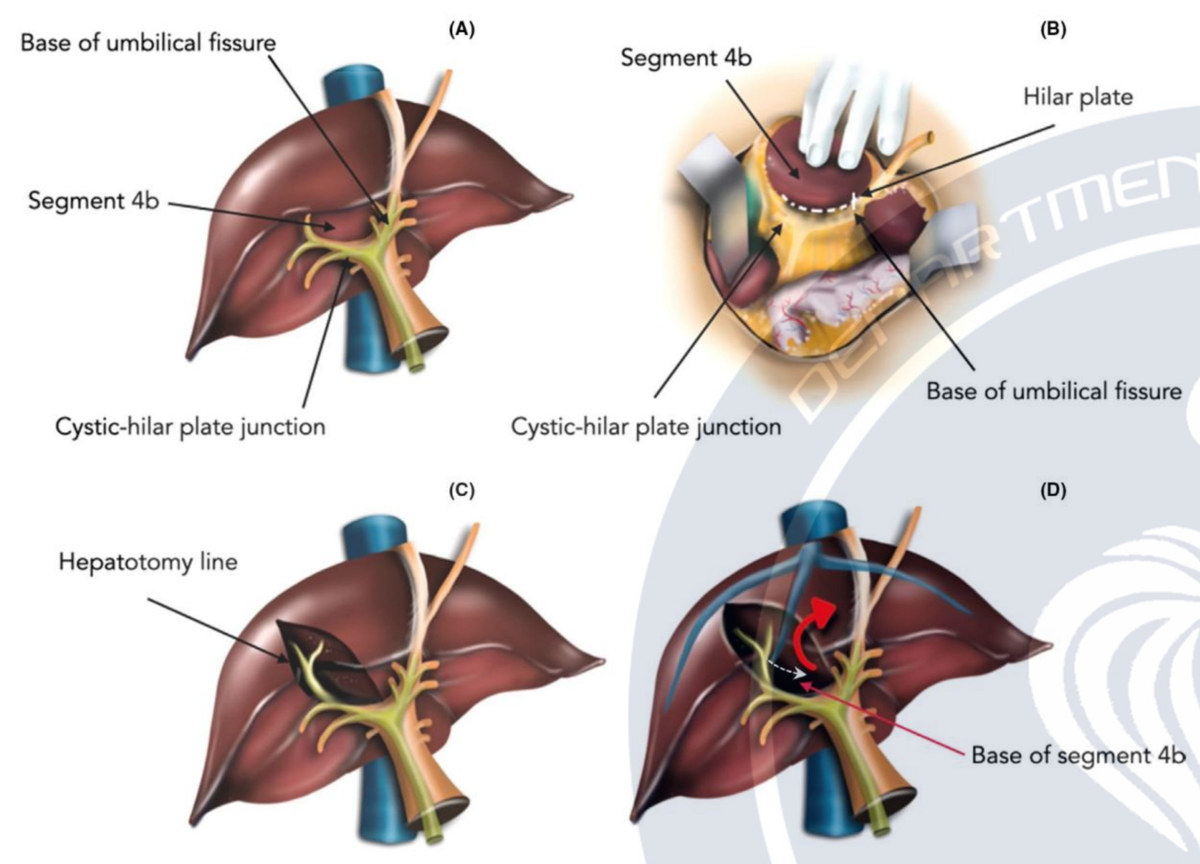
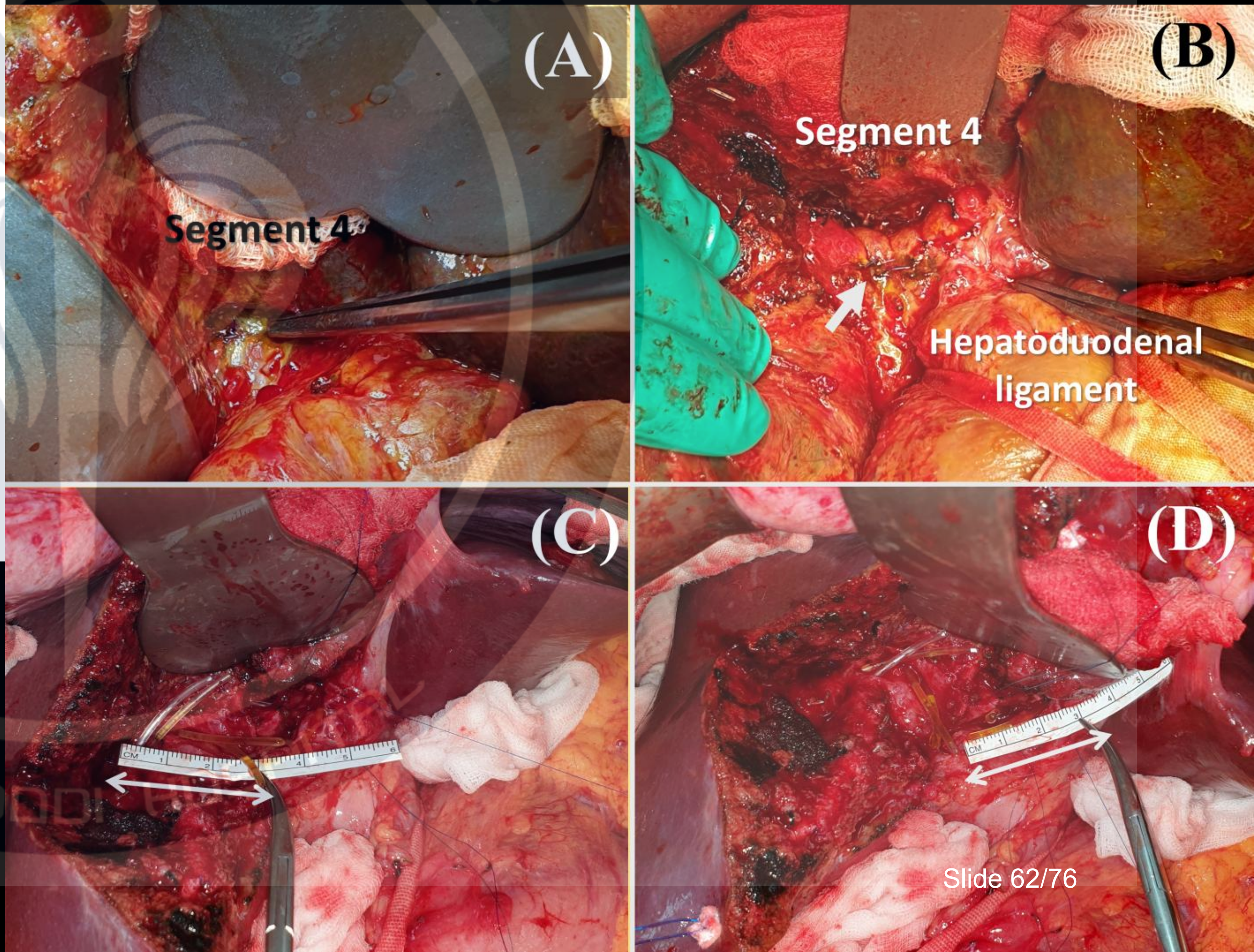


FIGURE 2 Schema of the total hilar exposure maneuver. (A) Step 1: Identifying landmarks; hilar bile duct located between the base of umbilical fissure and cystic-hilar plate junction, the hilar plate located below the inferior edge of segment 4b, and right anterior pedicle (RAP) located posteriorly to the cystic-hilar plate junction. (B) Step 2: Lowering of the hilar plate along the hilar bile duct by opening the peritoneum at the base of segment 4b. (C) Step 3: Performing hepatotomy along the RAP up to hepatic surface. (D) Step 4: Connecting the hepatotomy (white arrow) to the base of segment 4b and completely exposing the total hilar



2. Lowering the hilar plate
3. Hepatotomy along RAP
4. Connecting the hepatotomy to base of segment 4b

FIGURE 3 Intraoperative photographs after the total hilar exposure maneuver. (A) Pediatric feeding tubes are inserted into all bile duct openings, which are identified on intraoperative ultrasonography. (B) Exposure of the left and right hepatic ducts

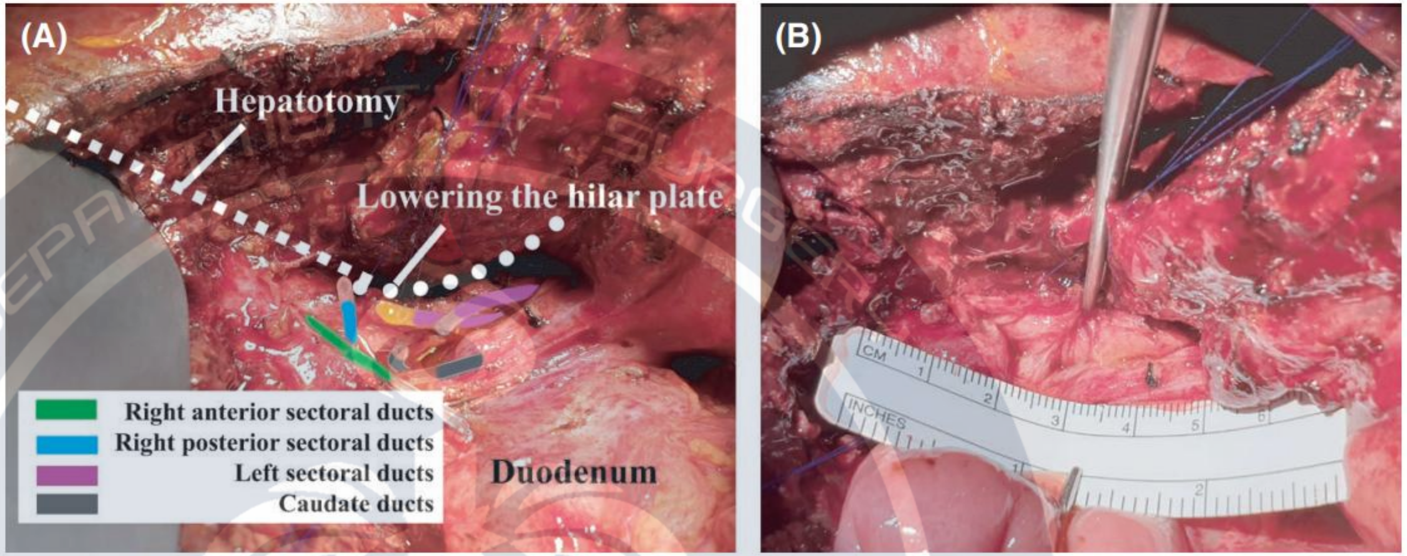


TABLE 2 Operative management and outcome

Case	Injury type[a]	Vascular injury	Hepatotomy	Lowering of hilar plate	Creation of subcutaneous jejunal limb	Total length of HJ (cm)	No. of HJs	Clavien–Dindo grade at 30 d	Achievement of primary patency
1	E3	RHA	Short[b]	Yes	Yes	3	1	None	Yes
2	E3	RHA	Short	Yes	Yes	3	1	None	Yes
3	E4[c]	RHA	Long[d]	Yes	Yes	3.5	2	III	Yes
4	E4	None	Long	Yes	Yes	6	2	None	Yes
5	E3	LPV	Long	Yes	Yes	4	1	III	Yes
6	E4	RHA	Long	Yes	Yes	5	1	None	Yes

Abbreviations: HJ, hepaticojejunostomy; LPV, left portal vein; RHA, right hepatic artery.

[a]Injury type was classified according to the classification by Strasberg et al.[5]

[b]Short hepatotomies extended from the middle of the hilum to the hepatic surface.

[c]No communication of right anterior and posterior bile duct.

[d]Long hepatotomies extended from the hilum to the hepatic surface.

Vasculobiliary injury

- HAI injury may accompany BDI
  - Association with an excisional injury of the common hepatic duct, due to the proximity of the artery and the duct
- 1/3 -> recognized at the time of cholecystectomy
  - The remaining patients having the injury identified in the early postoperative period if there was a bile leak, or later if they presented with jaundice
- Concomitant HAI : 12% to 47% of patients with LC related BDI
  - RHA : most common 90%
  - Main hepatic artery : 8%
  - Portal vein injury; often associated with HAI : 4%

C. Pulitanò et al. Concomitant arterial injury and laparoscopic bile duct injury. The American Journal of Surgery, Vol 201, No 2, February 2011

Vasculobiliary injury

Mechanism of injury

- The RHA is often at risk during LC, as it is present in Calot's triangle in 82% of the cases
- RHA is mistakened as cystic artery
- Misidentification of CBD as cystic duct -> division of CBD exposes RHA -> Errorneous assumption as posterior cystic artery

3 types of injury

- Transection of the RHA, usually being misidentified as the cystic artery; most common
- Damaged while attempting to control bleeding during the dissection
- Thrombosis of the hepatic artery, secondary to biliary peritonitis

C. Pulitanò et al. Concomitant arterial injury and laparoscopic bile duct injury. The American Journal of Surgery, Vol 201, No 2, February 2011

Vasculobiliary injury

Presentation

- Must be suspected in any patient with BDI referred for primary repair or refashioning of an unsuccessful primary repair
- Imagings
    - Exclude injury to either the arterial or portal venous systems
    - Identify the presence of a pseudoaneurysm -> follow from sepsis or traumatic injury
    - Most common CT scan finding suggestive of HAI is represented by the nonenhancement of the right lobe during the arterial phase
- Initial symptoms
    - Nonspecific, typically related to the effects of biliary leak or biliary obstruction rather than due to vascular-related complications
    - Specific early symptoms : bleeding, hemobilia, acute hepatic insufficiency, and sepsis related to right lobe atrophy, necrosis, and abscess formation

C. Pulitanò et al. Concomitant arterial injury and laparoscopic bile duct injury. The American Journal of Surgery, Vol 201, No 2, February 2011

Vasculobiliary injury

Consequences of vascular injury

- Blood supply of extrahepatic biliary system
  - Collateral vessels from the LHA and RHA
  - Plexus from posterior superior pancreaticoduodenal artery and RHA
- Isolated RHA injury is usually well-tolerated
- BDI with concomittant HAI -> increase the potential of ischemic stricture of the remaining external and Rt biliary tree
- Concomitant portal vein injuries
  - Not frequently reported
  - Associated with increased severity of the injuries as a normal portal circulation is necessary for recovery of the de-arterialized liver

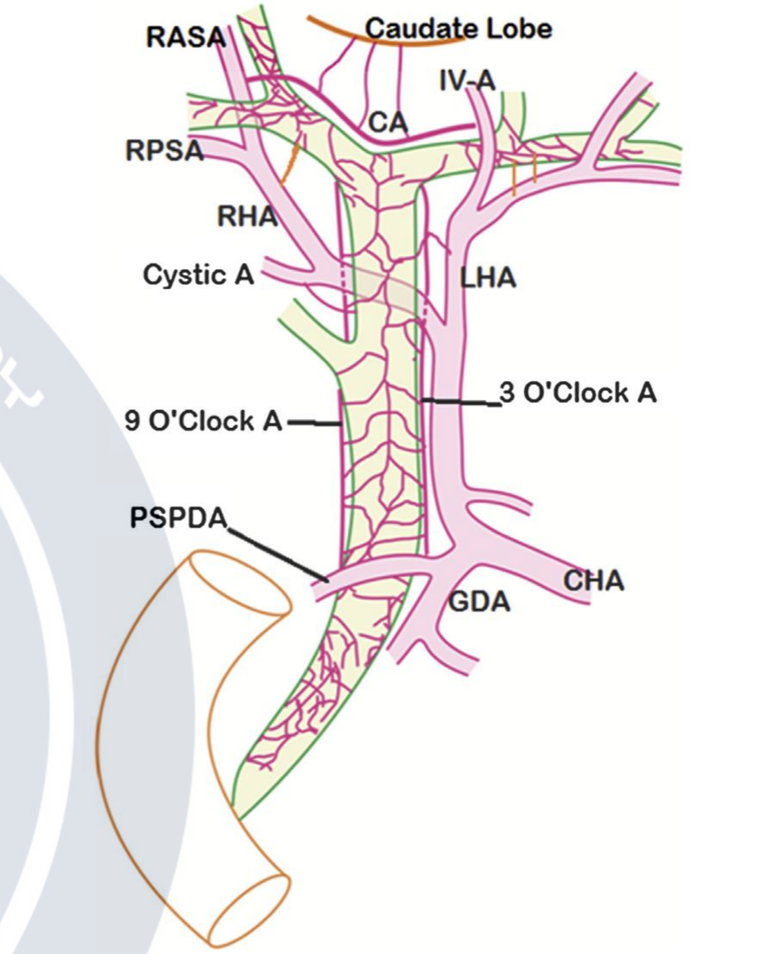


Figure 2 Normal arterial pattern of extrahepatic biliary tract. Supraduodenal CBD is primarily supplied by 3 o'clock (left) and 9 o'clock (right) marginal arteries contributed from posterior superior pancreaticoduodenal artery (PSPDA) from below and right hepatic (RHA), Left hepatic (LHA) and Cystic arteries from above. These marginal arteries are comparable to Paracholedochal Plexus (of Petren). Marginal arteries give small branches which form the Epicholedochal plexus. Above, the marginal arteries join the hilar plexus which supply the hilar ducts. Communicating Arcade (CA) connects RHA and LHA and is present cranial to the confluence of right and left hepatic ducts. The CA arises from right anterior sectoral artery (RASA) on the right and segment IV artery (IV A) on the left. RPSA – Right posterior sectoral artery.

C. Pulitanò et al. Concomitant arterial injury and laparoscopic bile duct injury. The American Journal of Surgery, Vol 201, No 2, February 2011
Ramesh Babu & Shama. J CLIN EXP HEPATOL 2014;4:S18–S26

Management

- Depends on evidence of liver injury and the timing of recognition of the HAI
- Interruption of the hepatic arterial flow is generally well tolerated in a healthy patient
- Repair of RHA is still controversy
  - Repair of RHA in intraoperative or early portoperative
    - Re-anastomosis using an end-to-end technique is usually possible only if the injury is related to a partial or complete transectional injury of the vessel, and is undertaken following immediate conversion to laparotomy
  - Ligating RHA due to well-toleration w/o important clinical consequence
  - Unfeasible vascular reconstruction -> Hepp-Couinaud reconstruction is an approach to avoid postop anastomotic stricture

C. Pulitanò et al. Concomitant arterial injury and laparoscopic bile duct injury. The American Journal of Surgery, Vol 201, No 2, February 2011

Management

- In late period, HAI may influence the necessity of resection of necrotic liver parenchyma
- Development of liver atrophy
  - Secondary to the association of arterial damage with systemic or portal hypotension
  - Probably involved when hemorrhage or sepsis is poorly controlled in the early period following BDI
- Portal vein injuries are usually managed by suture repair or occasional reconstruction of the occluded portal vein at the time of biliary reconstruction

C. Pulitanò et al. Concomitant arterial injury and laparoscopic bile duct injury. The American Journal of Surgery, Vol 201, No 2, February 2011

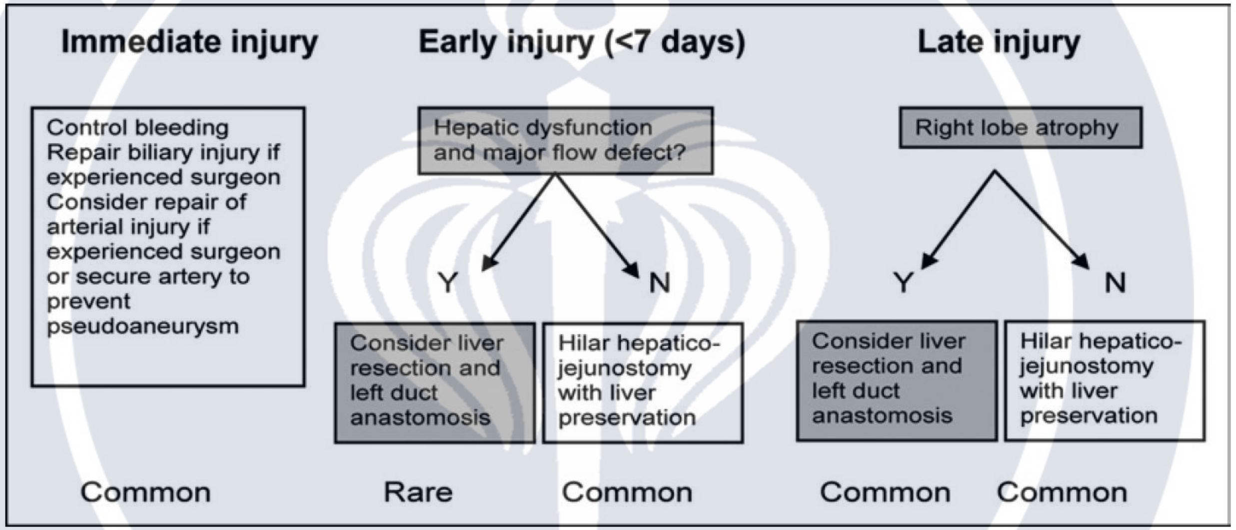


Figure 3 Suggested algorithm for the management of bile duct injury combined with hepatic artery injury in the immediate early and late settings. An indication of the relative frequency of scenarios is given.

C. Pulitanò et al. Concomitant arterial injury and laparoscopic bile duct injury. The American Journal of Surgery, Vol 201, No 2, February 2011

Outcome

- Clinical outcome of endoscopic treatment
  - Minor injury : ERCP -> success rate 90-97%
  - More severe BDI; lateral defects of major bile ducts -> slightly lower rate 85-89 %
  - Biliary stricture : progressive endoscopic stenting q 3-4 mo
    - Long term success rate 74-89 %
- Clinical outcome of surgical treatment
  - End-to-end anastomosis : almost always requires additional intervention
    - 66% underwent endoscopic dilatation, 32% underwent HJ
  - Hepaticojejunostomy anastomosis
    - Anastomotic stricture 4.1-69%
    - Median time to stricture 11-30 mo

Schreuder et al.Long-Term Impact of BDI.Dig Surg 2020;37:10–21

Outcome

BOX 42.3 Factors Associated With Stricture Recurrence or Poor Outcome After Operative Reconstruction

- Proximal stricture (Bismuth types 3 and 4)
- Multiple prior attempts at repair
- Portal hypertension
- Hepatic parenchymal disease (cirrhosis or hepatic fibrosis)
- End-to-end biliary anastomosis
- Surgeon inexperience
- Intrahepatic or multiple strictures
- Concurrent cholangitis or hepatic abscess
- Intrahepatic stones
- External or internal biliary fistula
- Intraabdominal abscess or bile collection
- Hepatic lobar atrophy
- Advanced age or poor general health

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HJ stricture

- ERCP is often not possible due to the altered anatomy
  - Traditional ERCP -> low cannulation success 33%
  - Double balloon enteroscopy ERCP(DBE-ERCP) + balloon dilatation/ stent insertion
- PTBD with balloon dilatation and internal drainage is generally applied
  - Requires 1–4 repeat dilatations and a period of biliary drainage of approximately 3 months
  - Overall success rates of 66-76% and low procedural morbidity of 11–13%
  - making PTBD with balloon dilatation a suitable first step in treatment before moving on to surgical revision
- Surgical revision of an HJ : Operative morbidity of 30–40%, but long-term results are good in approximately 90% of cases
  - A step-up approach starting with PTBD dilatation and moving on to surgical revision when PTBD fails seems advisable
- EUS guided hepaticogastrostomy

Choi Kevin Kyung Ho et al. Outcomes of patients… Endosc Int Open 2023; 11: E24–E31
Schreuder et al. Dig Surg 2020;37:10–21
Ogura et al.J Hepatobiliary Pancreat Sci. 2021;28:e34–e35

Bile Duct Injury During Cholecystectomy and Survival in Medicare Beneficiaries

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Cecilia Prela, PharmD
E. Patchen Dellinger, MD
Leighton Chan, MD, MPH

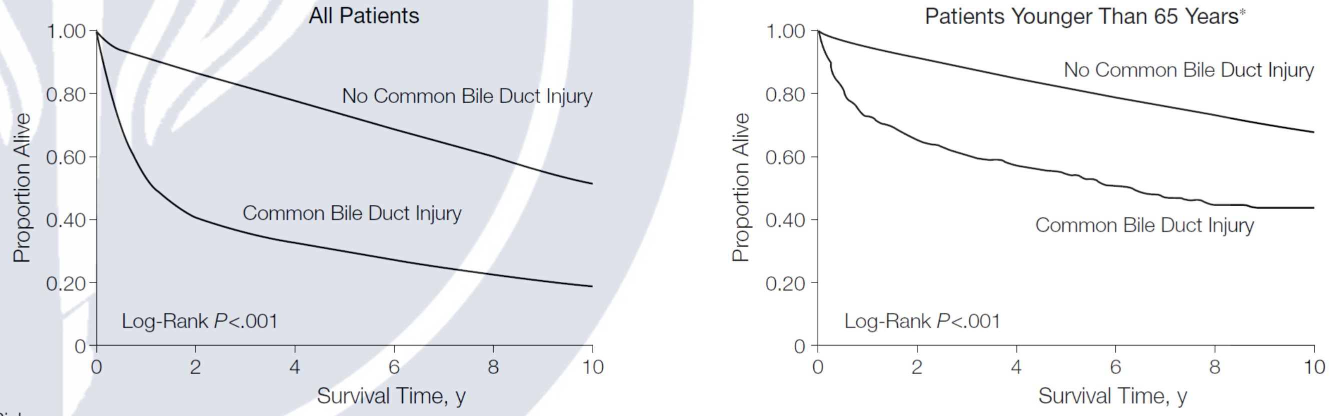
- JAMA Oct 22/29, 2003 – Vol 290, No 16
- Retrospective study using Medicare National Claims History Data linked to death records
- Determine survival after cholecystectomy, controlling for patients and surgeons factors

Table 1. Characteristics of Patients With and Without Common Bile Duct (CBD) Injury*

Variable	No CBD Injury (N = 1 562 450)	CBD Injury (n = 7911)
Patient-level variables		
Age-mean (SD), y†	71.4 (10.5)	73.5 (9.5)
Sex, % women†	62.9	53.9
Non-Hispanic white, %	88.8	88.2
Complex biliary disease, %†‡	10.9	14.2
Comorbidity index, mean (SD)†‡	0.06 (0.22)	0.76 (0.96)
Surgeon-level variables		
Age, mean (SD), y†	48.4 (9.5)	47.7 (9.6)
Sex, % men	96.7	96.6
Percent performed in first 20 cholecystectomies†§	24.8	35.1
Case order, mean (SD)†‖	64.3 (59.2)	62.9 (61.5)
General or specialist, %‖	95.6	95.5
Board certified, %†	80.8	82.4
Years since medical school graduation, mean (SD)†	22.1 (9.8)	21.5 (9.6)

*Adapted from Flum et al.[1]
†Differences statistically significant at $P<.001$.
‡The comorbidity index ranges from 0 to 3, with 3 representing the greatest comorbidity.
§Case order among Medicare patients starting January 1, 1992.
‖Specialty code designated as general surgeon or other surgical subspecialist.

Proportion Surviving After Common Bile Duct Injury



No. at Risk

Common Bile Duct Injury												
No	1 458 821	1 265 487	937 488	579 466	278 804	53 543	178 381	161 935	119 007	71 853	33 592	6422
Yes	7719	2942	2056	1288	633	143	576	375	265	154	70	14

Proportion of patients surviving after cholecystectomy with or without common bile duct injury.
*The mean age of those younger than 65 years was 54.8 years.

- 1/3 of patients died within follow up
- Most of the impact of CBD injury appeared in the first 2 years

Table 2. Cox Proportional Hazards of Death After Cholecystectomy by Common Bile Duct (CBD) Injury (N = 1 570 361)

Variable	Hazard Ratio (95% Confidence Interval) Adjusted*	Unadjusted
Patient factors		
CBD injury	2.79 (2.71-2.88)	4.09 (4.06-4.11)
Age per yearly increase†	1.06 (1.06-1.06)	1.06 (1.06-1.06)
Women‡	0.67 (0.66-0.67)	0.69 (0.68-0.70)
Non-Hispanic white‡	0.80 (0.79-0.80)	0.95 (0.94-0.95)
Charlson comorbidity index per increase in unit, scale 0-3†§	1.67 (1.66-1.68)	1.85 (1.84-1.85)
Surgeon factors		
Age†	1.00 (1.00-1.00)	1.00 (1.00-1.00)
Surgical specialist‡	0.95 (0.94-0.95)	0.88 (0.87-0.88)
Case considered complex‡	1.12 (1.11-1.13)	1.21 (1.20-1.22)
Each increase in the number of practice years†	1.00 (1.00-1.00)	1.00 (1.00-1.00)

*Each variable was adjusted for all other variables listed.
†The hazard estimate is for each increase in 1 unit compared with the value before it.
‡The hazard estimate is for the presence of this variable compared with those who were not positive for this variable.
§The value 3 for the comorbidity index indicates the greatest comorbidity.

- Total patients 1570361
- The HR significantly increased with advancing age, case complexiry and comorbidity index
- The level of experience of repairing surgeon was linked to survival

Table 3. Cox Proportional Hazards of Death After Common Bile Duct Injury for People With Complete Records (n = 7719)*

Variable	Hazard Ratio (95% Confidence Interval)
Patient factors	
Age per yearly increase†	1.03 (1.03-1.03)
Women‡	0.91 (0.70-1.18)
Non-Hispanic white‡	0.92 (0.83-1.00)
Charlson index per increase in unit, scale 0-3†§	1.84 (1.78-1.90)
Repairing surgeon factors	
Age†	1.00 (0.99-1.01)
Surgical specialist‡	1.02 (0.87-1.22)
Board certified‡	0.97 (0.88-1.08)
Same surgeon for cholecystectomy and repair‡	1.11 (1.02-1.20)
Each increase in the number of practice years‡	0.99 (0.97-1.00)
Each increase by 1 in the case-order experience†	0.98 (0.97-1.00)
Multiple repair operations	1.05 (0.97-1.14)

*Each variable was adjusted for patient and repairing surgeon characteristics.
†The hazard estimate is for each increase in 1 unit compared with the value before it.
‡The hazard estimate is for the presence of this variable compared with those who were not positive for this variable.
§The value 3 for the comorbidity index indicates the greatest comorbidity.

- 7719 patients with CBD injury with complete records
- Factors increase the hazards for death
  - Age
  - Comorbidity index
  - Same surgeon for cholecystectomy and repair

Thank You