Management of Iatrogenic Bile Duct Injuries: Role of the Interventional Radiologist[1]

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ONLINE-ONLY SA-CME

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LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

- List the imaging modalities that are most useful for evaluating bile duct injuries.
- Describe two systems for classifying bile duct injuries.
- Identify the most appropriate mode of treatment (endoscopic, percutaneous, surgical) for specific biliary injuries.

TEACHING POINTS

See last page

Bile duct injuries are infrequent but potentially devastating complications of biliary tract surgery and have become more common since the introduction of laparoscopic cholecystectomy. The successful management of these injuries depends on the injury type, the timing of its recognition, the presence of complicating factors, the condition of the patient, and the availability of an experienced hepatobiliary surgeon. Bile duct injuries may lead to bile leakage, intraabdominal abscesses, cholangitis, and secondary biliary cirrhosis due to chronic strictures. Imaging is vital for the initial diagnosis of bile duct injury, assessment of its extent, and guidance of its treatment. Imaging options include cholescintigraphy, ultrasonography, computed tomography, magnetic resonance cholangiopancreatography, endoscopic retrograde cholangiopancreatography, percutaneous transhepatic cholangiography, and fluoroscopy with a contrast medium injected via a surgically or percutaneously placed biliary drainage catheter. Depending on the type of injury, management may include endoscopic, percutaneous, and open surgical interventions. Percutaneous intervention is performed for biloma and abscess drainage, transhepatic biliary drainage, U-tube placement, dilation of bile duct strictures and stent placement to maintain ductal patency, and management of complications from previous percutaneous interventions. Endoscopic and percutaneous interventional procedures may be performed for definitive treatment or as adjuncts to definitive surgical repair. In patients who are eligible for surgery, surgical biliary tract reconstruction is the best treatment option for most major bile duct injuries. When reconstruction is performed by an experienced hepatobiliary surgeon, an excellent long-term outcome can be achieved, particularly if percutaneous interventions are performed as needed preoperatively to optimize the patient's condition and postoperatively to manage complications.

Abbreviations: ERCP = endoscopic retrograde cholangiopancreatography, MRCP = magnetic resonance cholangiopancreatography, PTBD = percutaneous transhepatic biliary drain, PTC = percutaneous transhepatic cholangiography

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Introduction

Bile duct injuries are an infrequent but potentially devastating complication of biliary tract surgery, with cholecystectomy accounting for the largest proportion of such injuries. The annual incidence of bile duct injuries increased from approximately 0.2% in the era of open cholecystectomy to approximately 0.5% after laparoscopic cholecystectomy became widely available (1–3). Biliary injuries are associated with high morbidity and mortality, impaired quality of life, and substantial financial burdens to patients and society (3–5).

Optimal management of biliary injuries is achieved with a multidisciplinary approach. Successful management depends on the type of injury, timing of injury recognition, presence of complications, condition of the patient, and availability of experienced hepatobiliary surgeons (6). Radiologists play a key role in diagnosis and treatment. Imaging is vital for initial diagnosis, assessment of the extent of injury, and preprocedural planning. Depending on the type of injury, appropriate management methods may include endoscopic, percutaneous, and surgical interventions. The article describes the manifestations, diagnosis, classification, and management of iatrogenic bile duct injuries, with emphasis on the role of the interventional radiologist.

Clinical Manifestations

The clinical manifestations of bile duct injuries depend on the timing of injury recognition, type of injury, and presence of complications. An estimated 25%–32% of bile duct injuries are recognized at laparoscopic cholecystectomy and may be repaired immediately if a surgeon with experience in bile duct repair is available (6). Biliary repair performed by a surgeon without such experience is associated with increased morbidity and mortality and a prolonged hospital stay (3,6). Biliary injuries that are not recognized intraoperatively may become manifest days, months, or (rarely) years later (7,8). Patients may present with signs and symptoms of bile leakage or bile duct transection or ligation, such as jaundice, biliary peritonitis, and cholangitis; however, the greater frequency of nonspecific initial symptoms such as abdominal pain, malaise, nausea, and anorexia may account for the frequent delays in diagnosis (7–10). Later manifestations may include recurrent cholangitis and secondary biliary cirrhosis due to strictures (7).

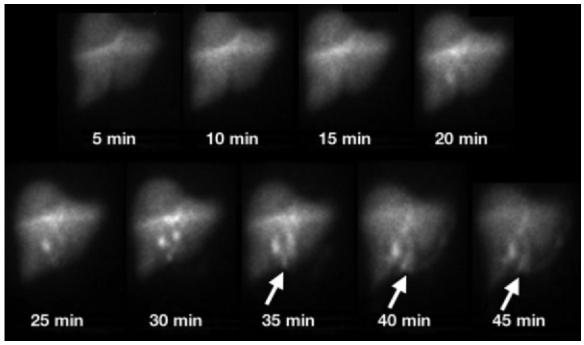


Figure 1. Image series from cholescintigraphy in a 37-year-old woman with right upper quadrant pain 10 days after laparoscopic cholecystectomy demonstrates progressive accumulation of the radiopharmaceutical in the gallbladder fossa and subhepatic space (arrows), a finding indicative of bile leakage.

Figure 2. Axial contrast material–enhanced CT image, obtained in a 54-year-old woman with increasing jaundice 2 weeks after laparoscopic cholecystectomy, depicts intrahepatic biliary duct dilatation and a surgical clip positioned across the proximal common hepatic duct (arrow), findings indicative of ligation of the common hepatic duct.

Diagnostic Imaging Techniques

Teaching Point

Imaging is vital for establishing the diagnosis, delineating the extent of injury, and planning appropriate intervention. Optional imaging modalities include cholescintigraphy, computed tomography (CT), ultrasonography (US), magnetic resonance cholangiopancreatography (MRCP), endoscopic retrograde cholangiopancreatography (ERCP), percutaneous transhepatic cholangiography (PTC), and fluoroscopy with injection of a contrast medium via a surgically or percutaneously placed catheter with bilious drainage due to a bile leak. Because each option has different advantages and limitations, many patients undergo several imaging studies for diagnostic evaluation.

Figure 3. Axial contrast-enhanced arterial phase CT image, obtained in a 34-year-old woman referred from an outside hospital after common hepatic duct transection during attempted laparoscopic cholecystectomy, shows decreased enhancement of the right lobe of the liver relative to that of the left lobe, a finding suggestive of right hepatic artery injury. Ligation of the artery was found at subsequent surgery.

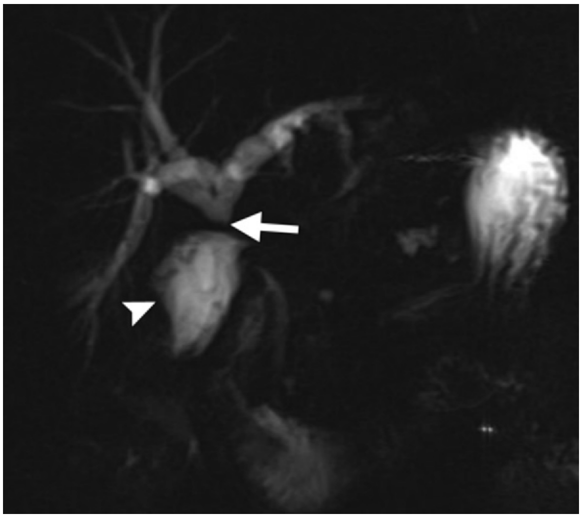
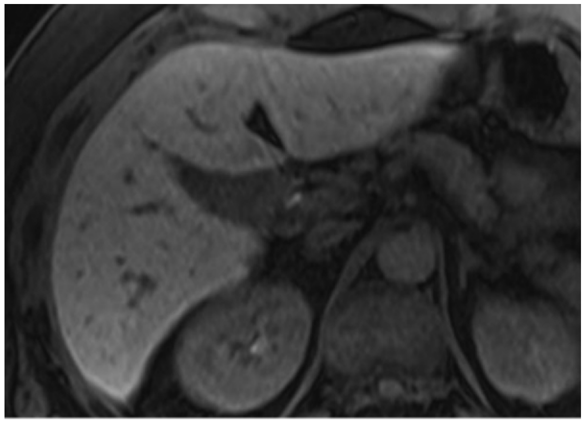


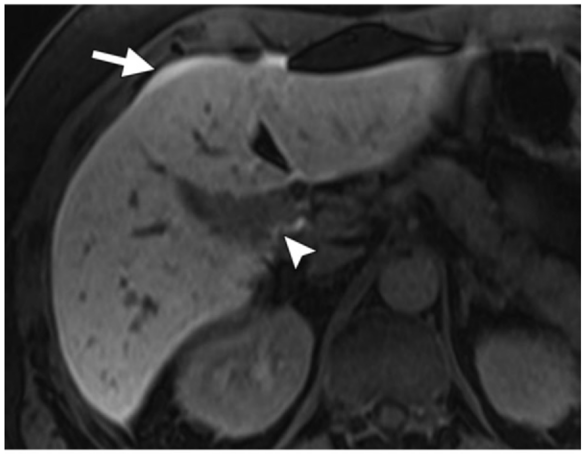
Figure 4. Oblique coronal maximum intensity projection image from MRCP in a 63-year-old woman with jaundice and abdominal pain after laparoscopic cholecystectomy demonstrates intrahepatic biliary ductal dilatation, obstruction of the common hepatic duct (arrow), and a fluid collection in the gallbladder fossa (arrowhead).

Cholescintigraphy has high accuracy for the detection of bile leaks (Fig 1). However, its utility for locating the site of ductal injury and, thus, for planning treatment is limited by poor spatial resolution (11,12).

CT and US can depict fluid collections, biliary duct dilatation, and associated arterial injuries (Figs 2, 3). CT has been reported to have higher sensitivity than US for detecting fluid collections and associated arterial injuries (9,13).



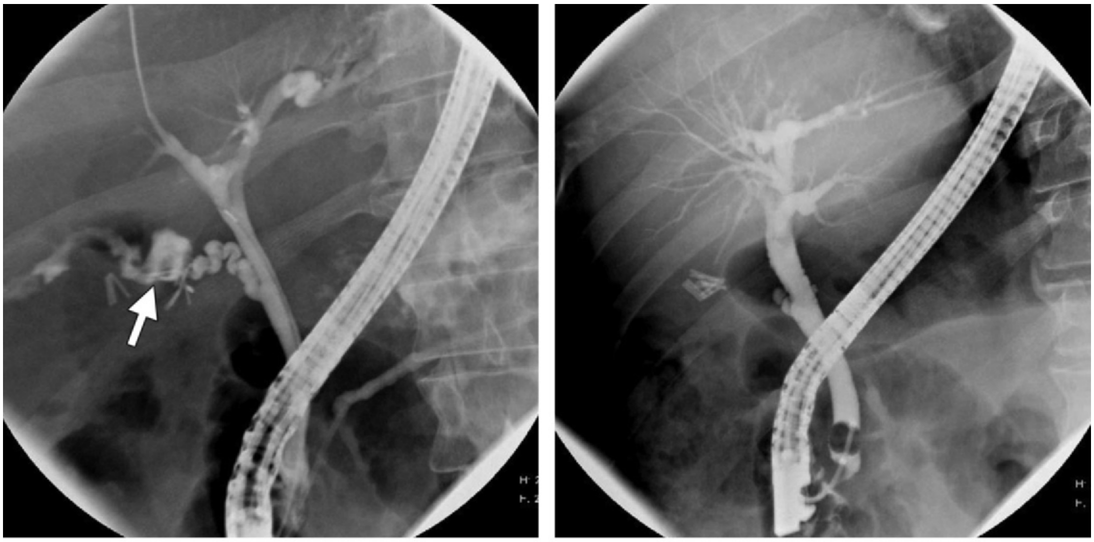
a.



b.

Figure 5. Bile duct injury from attempted laparoscopic cholecystectomy in a 39-year-old man. Axial T1-weighted MRCP images obtained before **(a)** and 30 minutes after **(b)** intravenous injection of gadoxetate disodium show accumulation of the contrast medium within perihepatic fluid (arrow in **b**) and a region of active extravasation of the contrast medium (arrowhead in **b**) adjacent to the common bile duct. A Strasberg type D laceration was found in the duct wall at subsequent surgery.

MRCP is noninvasive, does not require the use of a contrast medium, and provides excellent delineation of the biliary anatomy proximal and distal to the level of injury, unlike ERCP and PTC (Fig 4) (14,15). MRCP facilitates the identification of fluid collections and, if performed with use of an intravenous contrast medium, arterial injuries. Dynamic contrast-enhanced MRCP with a hepatocyte-selective contrast agent with biliary excretion allows a functional assessment of the biliary tree for detection and localization of bile leaks (Fig 5).



a. b.

Figure 6. **(a)** ERCP image obtained in a 58-year-old man with abdominal pain after laparoscopic cholecystectomy demonstrates bile leakage from the cystic duct stump (arrow). **(b)** ERCP image obtained 8 weeks later, after stent placement in the common duct and biloma drainage, shows no bile leakage.

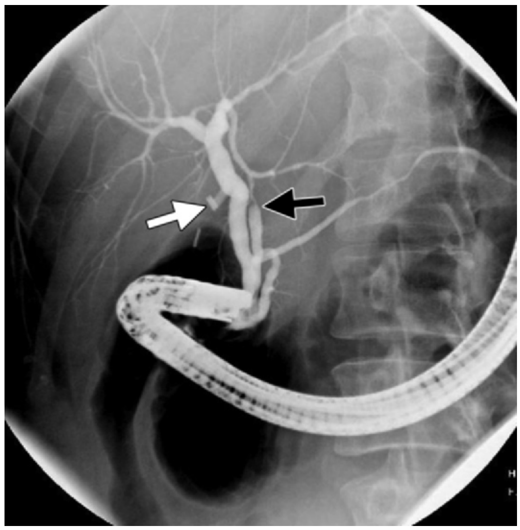


Figure 7. ERCP image obtained in a 35-year-old woman with persistent abdominal pain and mildly elevated levels of alkaline phosphatase and transaminases after laparoscopic cholecystectomy shows a lack of opacification of the posterior right segmental intrahepatic bile ducts, with an abnormally low insertion of the right posterior duct (white arrow). These findings, which were overlooked at the initial image interpretation, were retrospectively recognized to indicate ligation of an aberrant right posterior hepatic duct. Black arrow = cystic duct stump.

The accuracy of contrast-enhanced MRCP performed with a hepatocyte-selective contrast agent for the detection of bile leakage is close to 100%, and the exact location of leakage can be determined in approximately 79%–85% of such examinations (16,17).

With ERCP, the biliary system is evaluated distal to the level of injury. ERCP is more invasive than MRCP, but it allows simultaneous therapeutic interventions such as the placement of biliary stents and drainage catheters, which are standard for treating injuries such as stenoses of the common duct and bile leaks from the cystic duct stump or small peripheral ducts, which require percutaneous drainage (Fig 6) (18). The main limitations of ERCP are that it does not allow evaluation of the part of the biliary tree proximal to a major duct transection or ligation and has limited utility after surgical biliary-enteric anastomosis. In addition, transection or ligation of an aberrant right hepatic bile duct is frequently overlooked at ERCP (Fig 7) (19).

PTC is the imaging study of choice when interventions such as percutaneous transhepatic biliary drain (PTBD) placement are required to decompress an obstructed biliary system and control bile leakage. PTC is superior to ERCP for evaluating proximal bile duct injuries, common duct ligation or transection, and transection

Table 1
Bismuth Classification System for Bile Duct Injuries

Type	Description
1	Distal CHD stricture with a CHD stump > 2 cm long
2	Proximal CHD stricture with a CHD stump < 2 cm long
3	Hilar stricture with no CHD stump but with preservation of the hilar confluence
4	Hilar stricture with loss of communication between the right and left hepatic ducts
5	Aberrant right hepatic duct stricture with or without concomitant CHD stricture

Source.—Data are from reference 27. CHD = common hepatic duct.

Table 2
Strasberg Classification System for Bile Duct Injuries

Type*	Description
A	Leak from the cystic duct or a small duct in the liver bed
B	Occlusion of an aberrant right hepatic duct
C	Transection of an aberrant right hepatic duct without ligation
D	Lateral injury to a major bile duct
E1	Distal CHD stricture with a CHD stump > 2 cm long
E2	Proximal CHD stricture with a CHD stump < 2 cm long
E3	Hilar stricture with no CHD stump but with preservation of the hilar confluence
E4	Hilar stricture with loss of communication between the right and left hepatic ducts
E5	Aberrant right hepatic duct stricture with or without concomitant CHD stricture

Source.—Data are from reference 28.
*Strasberg types E1–E5 correspond to Bismuth types 1–5. CHD = common hepatic duct.

or ligation of an aberrant right hepatic bile duct (Fig 8) (6,19–23). PTC is an invasive procedure with an approximately 2% risk for major complications (24). If diagnosis is the sole purpose of the imaging examination, the use of a less invasive modality should be considered (25).

Fluoroscopy performed during the injection of a contrast medium via an existing surgically

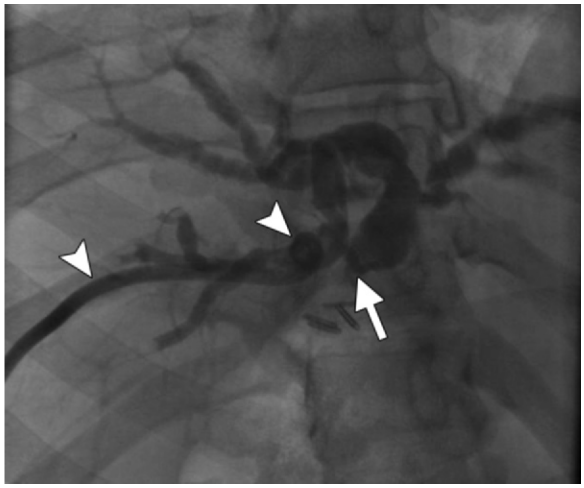


Figure 8. Image obtained with PTC in a 16-year-old female patient with abdominal pain and hyperbilirubinemia after laparoscopic cholecystectomy demonstrates biliary duct dilatation due to common hepatic duct ligation (arrow). A biliary drain inserted during PTC is also seen (arrowheads). ERCP was attempted before PTC but did not allow visualization of the biliary tree proximal to the injury site.

or percutaneously placed catheter with bilious drainage may opacify the bile ducts via the site of a bile leak. This may delineate the site of injury and facilitate PTBD placement, which can be difficult in the absence of bile duct dilatation. However, this technique should not be used in patients who show signs of infection, and it is most likely to be successful in bilomas that are small or that have undergone sufficient drainage to allow the biloma cavity to collapse around the catheter (22,23).

Classification Systems

Multiple systems have been proposed for classifying biliary injuries, but none is universally accepted (26). The Bismuth classification system originated in the early 1980s, in the era of open cholecystectomy (Table 1) (27). The Strasberg classification system, an expansion of the Bismuth system, originated in the 1990s and includes various types of laparoscopic bile duct injuries (Table 2, Fig 9) (28). In general, the type of injury correlates with the mode of management; however, no existing classification system takes into account all therapeutic and prognostic implications (6).

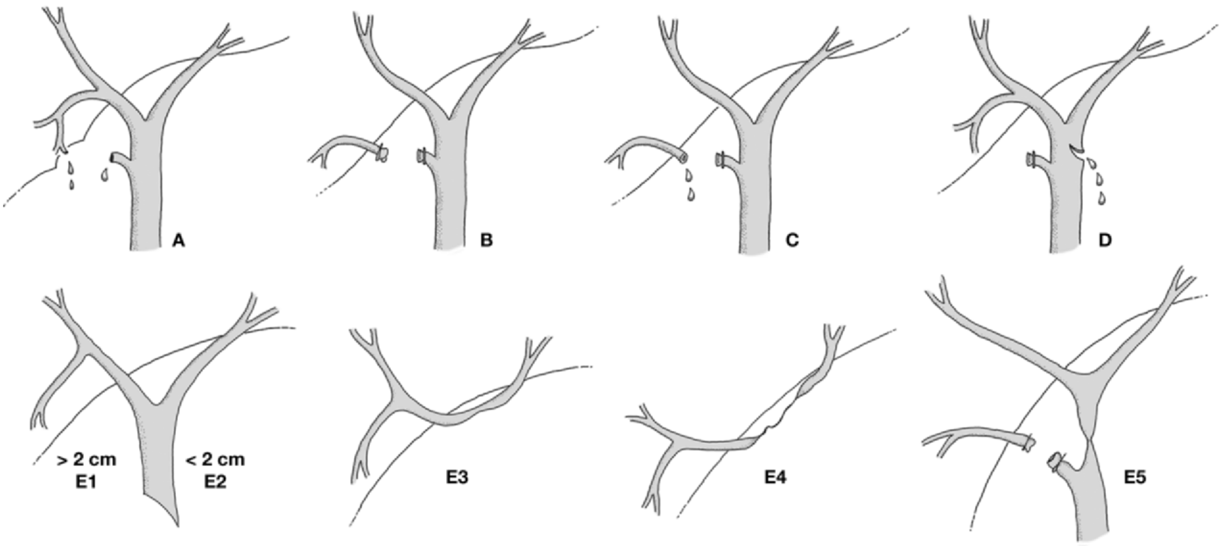


Figure 9. Drawings show the Strasberg system for classifying bile duct injuries. Type A injury is characterized by bile leakage from the cystic duct or small ducts in the liver bed; type B, by ligation of part of the biliary tree (almost invariably, an aberrant right hepatic duct); type C, by transection without ligation of an aberrant right hepatic duct; type D, by lateral injury to a major bile duct; type E1, by stricture of the distal common hepatic duct, with a common hepatic duct stump longer than 2 cm; type E2, by stricture of the proximal common hepatic duct, with a common hepatic duct stump less than 2 cm long; type E3, by a stricture of the hilar duct, with no residual common hepatic duct stump but with preservation of the hilar confluence; type E4, by a hilar duct stricture with involvement of the confluence and loss of communication of the right and left hepatic ducts; and type E5, by involvement of an aberrant right segmental duct alone or in addition to the common hepatic duct. (Reprinted, with permission, from reference 28.)

Initial Management

Teaching Point

Initial management of bile duct injuries is focused on stabilizing the patient's status, draining bilomas and abscesses, establishing biliary drainage, and obtaining a complete cholangiographic characterization of the injury (6,7,23). Stabilization methods include intravenous fluid hydration and electrolyte replenishment as needed. Antibiotic therapy should be initiated in patients with evidence of cholangitis or infected fluid collections (23).

CT is probably the most useful and most widely available noninvasive imaging modality for guiding initial management by allowing the identification of drainable fluid collections, biliary obstruction, and lobar atrophy or biliary cirrhosis due to long-standing obstruction (9,21). MRCP, ERCP, or PTC should be performed for complete characterization of the type and extent of injury when the patient's condition is stable. The selection of a specific cholangiographic modality is based on the type of injury indicated by the initial imaging findings and clinical manifestations and depends on the availability of cholangiographic expertise (6,7,23). Incomplete cholangiographic characterization of bile duct injuries is associated with poor surgical outcomes (29). Because MRCP is noninvasive and allows evaluation of the entire biliary tree, some authors have proposed that contrast-enhanced MRCP with a hepatocyte-selective contrast agent be performed as the initial study in patients in whom bile leakage is suspected, both for diagnosis and for guidance of subsequent endoscopic, percutaneous, and surgical interventions (17).

Once initial damage control is achieved and the type and extent of the biliary injury are established, definitive surgical repair can be performed if needed. Percutaneous interventions also may serve as definitive treatment for some types of injuries (23).

Percutaneous Interventions

Biloma Drainage

Most bilomas can be drained percutaneously with the Seldinger technique by using a combination of US and fluoroscopy or CT for imaging guidance (9). Because the symptoms of bile collections in the abdomen are often subtle, diagnosis and treatment are frequently delayed (9).

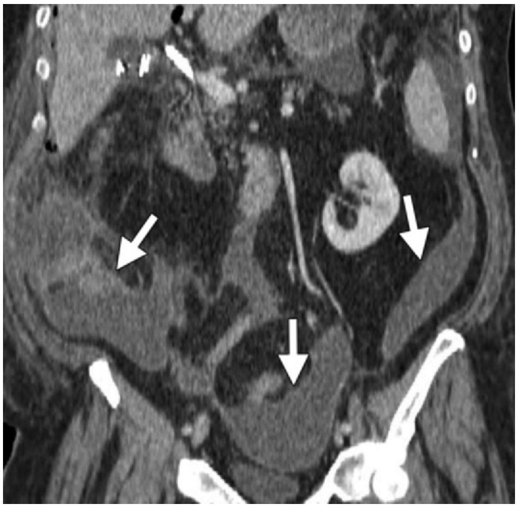


Figure 10. Coronal reformatted image from contrast-enhanced CT in a 58-year-old man with worsening abdominal pain 14 days after laparoscopic cholecystectomy demonstrates rimlike enhancement and stranding around multiple abdominal and pelvic fluid collections (arrows). Purulent bile was obtained at percutaneous drainage. The patient previously had undergone stent placement for a common duct leak discovered at postoperative ERCP, but fluid drainage was not performed at that time.

a.

b.

Figure 11. Bile duct injury in a 35-year-old woman with worsening abdominal pain, nausea, and vomiting after laparoscopic cholecystectomy. Initial PTC demonstrated bile leakage, but the exact source was not definitively determined. An internal-external biliary drain was placed to divert bile flow away from the leak, and a biloma drain was placed in the right lower quadrant. **(a)** Follow-up cholangiogram obtained by injecting a contrast medium through the internal-external biliary drain 3 days after its placement shows leakage from a small right peripheral duct (arrowhead). **(b)** Follow-up cholangiogram, obtained 4 weeks after drain placement, depicts resolution of the leak. The drains were removed and no additional intervention was needed.

Teaching Point

Fluid collections that are known or suspected to contain bile should be drained promptly; delayed drainage is associated with an increased incidence of serious complications, such as abscess formation, cholangitis, and sepsis (Fig 10) (9). Bile leaks from small peripheral ducts (eg, ducts of Luschka) can be definitively treated with a combination of percutaneous drainage and either PTBD placement or endoscopic common duct stent placement to divert bile flow away from the leakage site (Fig 11) (23).

PTC with PTBD Placement

Teaching Point

Complete ductal ligation or transection, proximal duct injury, and transection or ligation of an aberrant right hepatic bile duct usually require PTC with PTBD placement for biliary decompression, diversion, or both (19–23). The right bile ducts are accessed from the midaxillary line with fluoroscopic guidance. The entry site should be at the

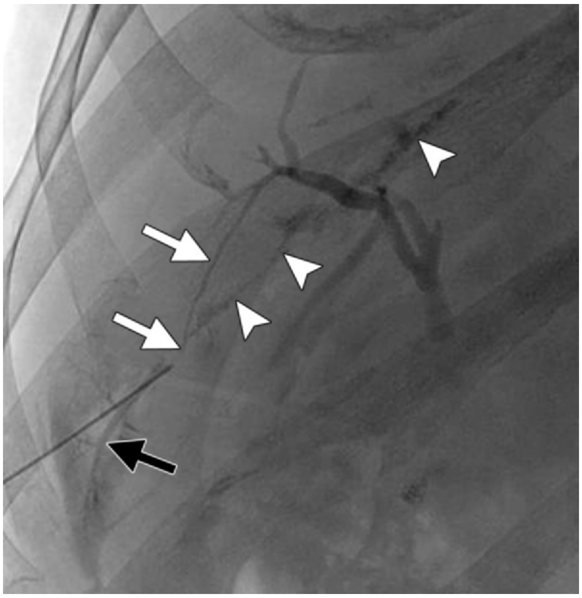


Figure 12. PTC performed with a right midaxillary approach demonstrates opacification of the right bile ducts from a small peripheral bile duct branch (white arrows). Contrast material in the bile ducts should flow slowly toward the hilum, whereas arterial and portal venous contrast material (black arrow) flows rapidly away. Contrast material is seen along the needle tract as the needle is withdrawn (arrowheads).

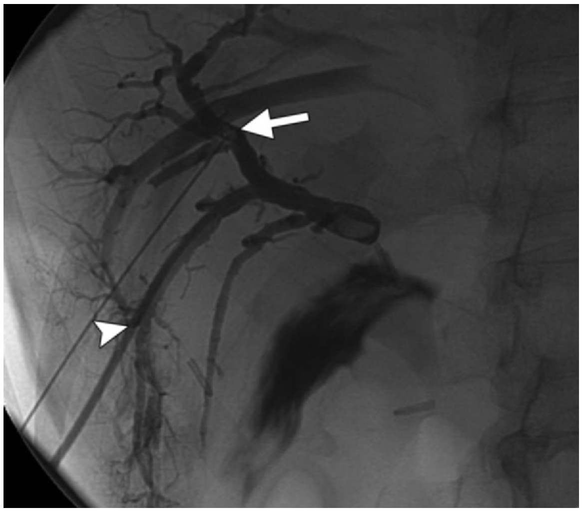


Figure 13. PTBD placement in a patient with a ligated aberrant right posterior hepatic duct after laparoscopic cholecystectomy (same patient as in Fig 7). PTC image shows insertion of the access needle in too central a branch of the isolated right posterior duct (arrow), with an increased risk for arterial or portal venous bleeding from PTBD placement. In addition, the angle of entry may be too acute for passage of a wire distally. Opacification of the bile ducts with contrast medium injected at the initial access site facilitates placement of the PTBD in a more peripheral duct branch (arrowhead).

level of the inferior portion of the right hepatic lobe and along the superior margin of the rib to minimize the risks of pleural transgression and intercostal neurovascular bundle injury, respectively. The left bile ducts are accessed with a subxiphoid approach by using US for guidance. With either approach, a 21- or 22-gauge needle is passed into the liver and slowly withdrawn with fluoroscopic guidance, while a contrast medium is slowly injected to opacify the bile duct (Fig 12). If it becomes apparent that the needle has been inserted into a duct segment that is sufficiently peripheral, the drainage catheter can be placed in that segment. If the opacified duct is too central or the angle of entry of the needle is suboptimal, a second needle is inserted with fluoroscopic guidance into a more peripheral duct that is suitable for catheter placement (Fig 13) (20,22,30).

In patients with cholangitis, excessive manipulation of catheters in the bile ducts should be avoided to reduce the risk of sepsis. In these patients, an external drain may be placed for 2–4 days to allow decompression and a course of antibiotic therapy to be administered before internal catheter placement is attempted (23). In patients without cholangitis, placement of an internal-external catheter may be possible from the start (23). In patients with injuries that preclude the passage of a catheter into the duct (eg, complete ligation of the common duct), an external drainage catheter positioned immediately proximal to the level of ductal obstruction provides a palpable landmark for the surgeon when the site is obscured by scar tissue (Fig 14) (23).

Injuries of the common duct usually require the placement of only one drain, whereas hilar injuries with high-grade strictures of the left and right hepatic ducts or loss of continuity in the ducts require bilateral drain placement (Fig 15) (22,23). Transection or ligation of an aberrant right hepatic duct requires targeted drain placement in the affected segments of the biliary tree (Fig 16) (19,22,23).

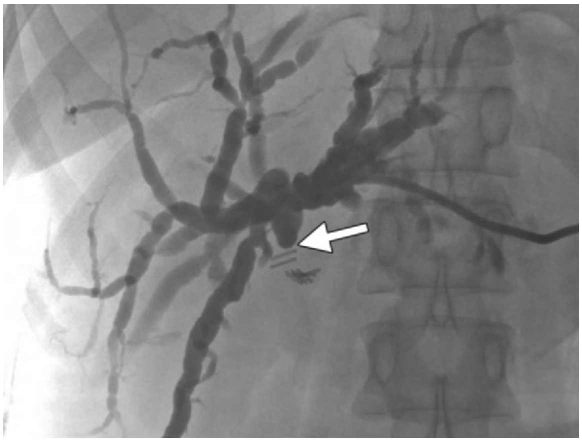
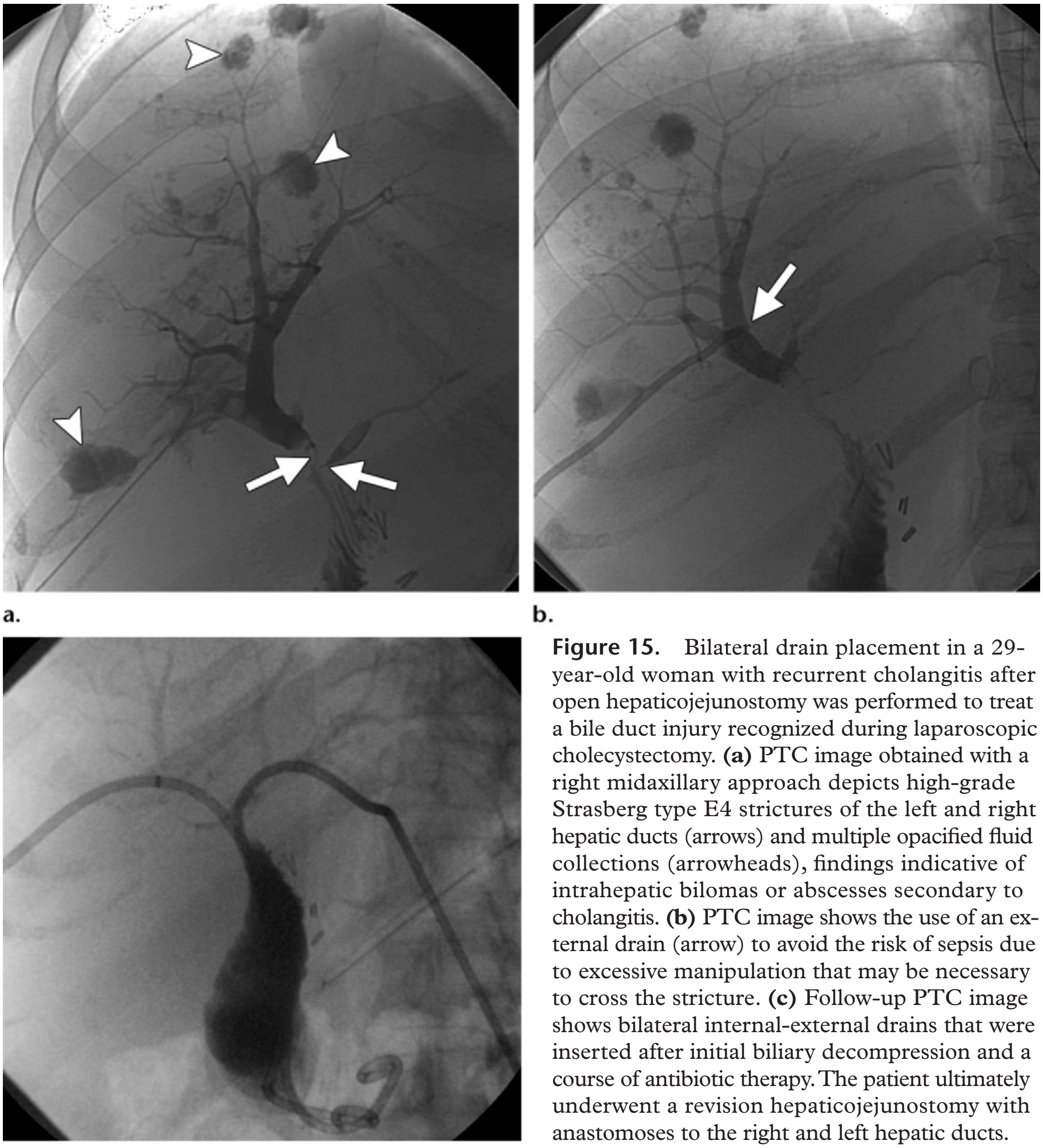


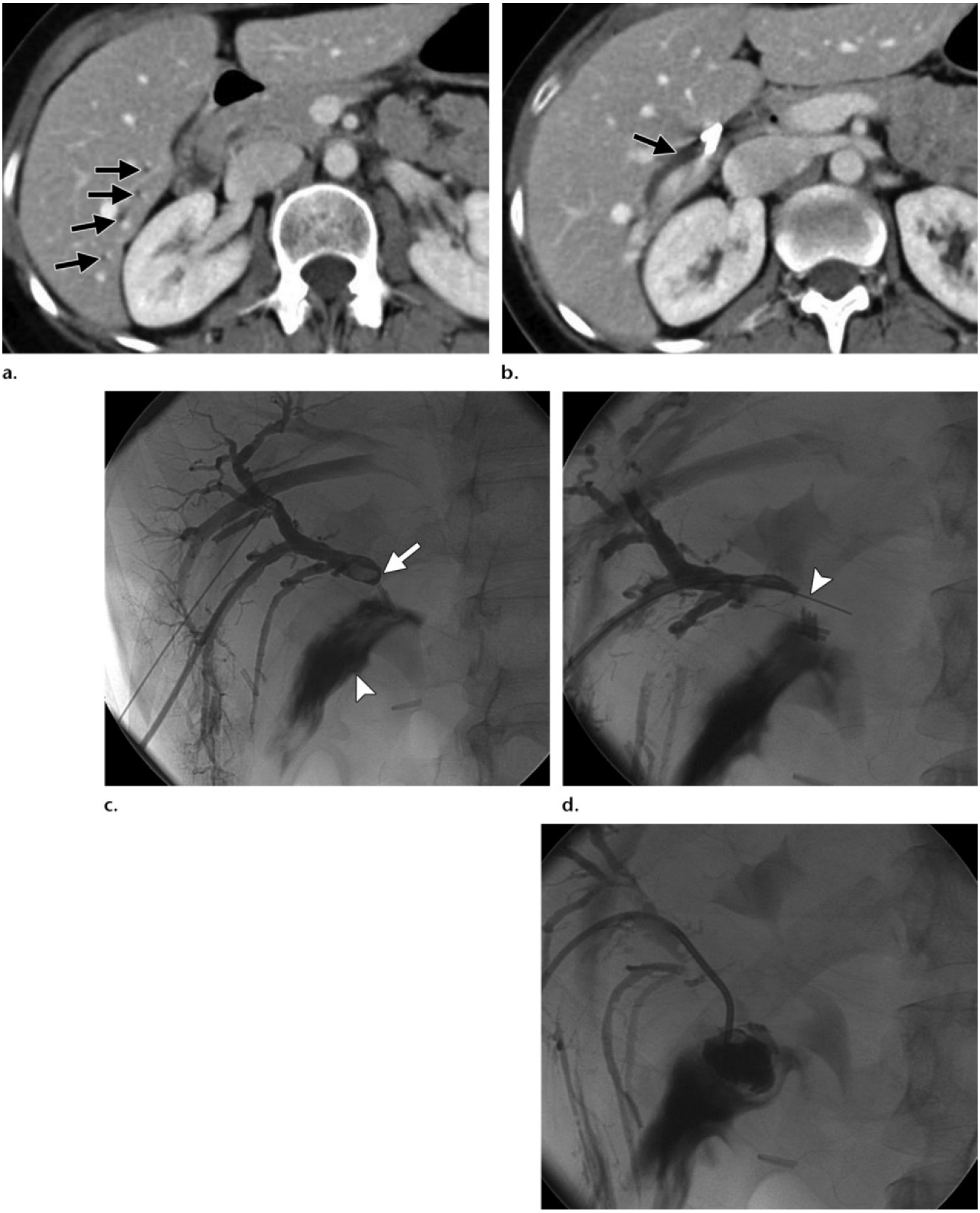
Figure 14. PTC image obtained in a 54-year-old woman with increasing jaundice 2 weeks after laparoscopic cholecystectomy demonstrates complete occlusion of the common hepatic duct (arrow). An external PTBD was placed immediately proximal to the level of obstruction.



a. b. c.

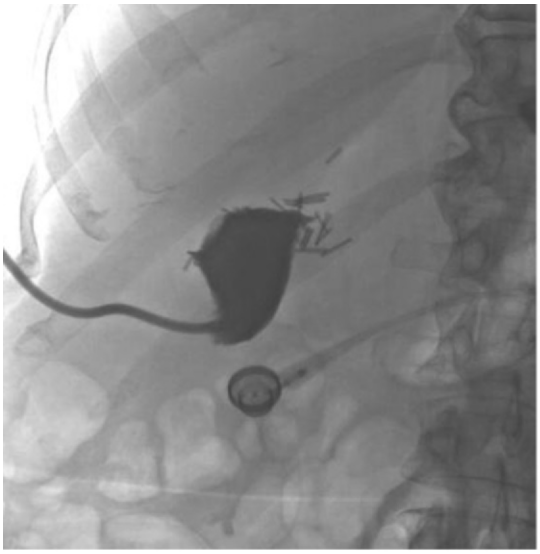
Figure 15. Bilateral drain placement in a 29-year-old woman with recurrent cholangitis after open hepaticojejunostomy was performed to treat a bile duct injury recognized during laparoscopic cholecystectomy. **(a)** PTC image obtained with a right midaxillary approach depicts high-grade Strasberg type E4 strictures of the left and right hepatic ducts (arrows) and multiple opacified fluid collections (arrowheads), findings indicative of intrahepatic bilomas or abscesses secondary to cholangitis. **(b)** PTC image shows the use of an external drain (arrow) to avoid the risk of sepsis due to excessive manipulation that may be necessary to cross the stricture. **(c)** Follow-up PTC image shows bilateral internal-external drains that were inserted after initial biliary decompression and a course of antibiotic therapy. The patient ultimately underwent a revision hepaticojejunostomy with anastomoses to the right and left hepatic ducts.

Figure 16. Ligated aberrant right hepatic duct in a 35-year-old woman with persistent abdominal pain and mildly elevated levels of alkaline phosphatase and transaminases after laparoscopic cholecystectomy (same patient as in Figs 7 and 13). **(a, b)** Axial contrast-enhanced CT images show dilatation of multiple right posterior hepatic ducts (arrows in **a**) converging toward surgical clips in the hilum (arrow in **b**), findings suggestive of a ligated right posterior hepatic duct (Strasberg type B injury). **(c)** PTC image helps confirm the presence of a ligated right posterior hepatic duct (arrow); no communication is seen with the common duct. Contrast material accumulation in the subhepatic space (arrowhead) is due to inadvertent peritoneal penetration by the needle while accessing the right posterior ducts. A catheter and wire were advanced to the level of ligation. **(d)** PTC image shows the wire, which was reversed to allow the use of its stiff end (arrowhead) to perforate the duct and gain access to the peritoneum. **(e)** PTC image shows placement of a drainage catheter through the ligated duct and into the subhepatic space to facilitate identification during surgical repair. The patient later underwent hepaticojejunostomy with an anastomosis to the ligated duct.



a. b. c. d. e.

Figure 17. U-tube placement at PTC in a 62-year-old woman with injury to the proximal common duct (Strasberg type E3 injury) from laparoscopic cholecystectomy. **(a)** PTC image obtained after contrast medium injection into a previously placed biloma drain demonstrates no retrograde opacification of bile ducts. **(b)** PTC image depicts a proximal obstruction of the common hepatic duct (arrow). A catheter and wire were advanced to the level of the obstruction, and the wire was manipulated through the site of obstruction, into the biloma cavity. **(c)** PTC image shows snaring of the wire (arrow) via the biloma drainage tract to create through-and-through access for placement of a straight drain.



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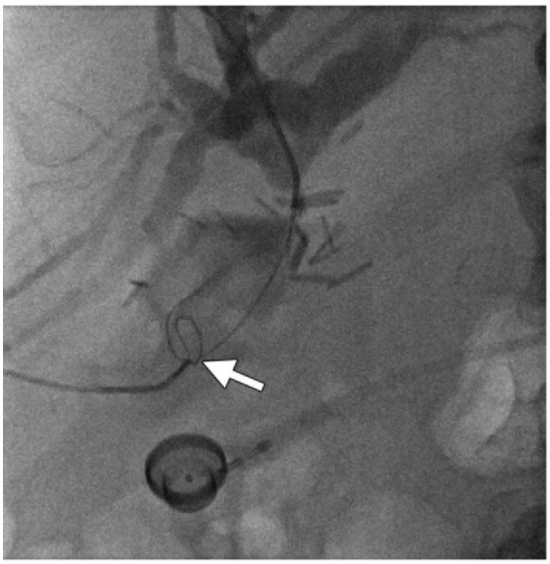


c.

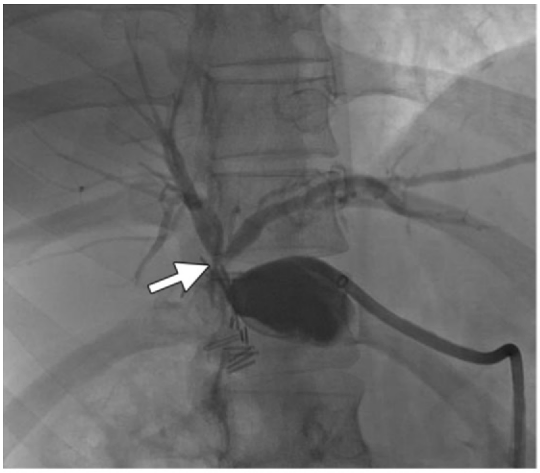
U-Tube Placement

U-tube placement is a useful drainage technique for the management of bile duct injuries requiring simultaneous biliary diversion and biliary drainage, such as common duct or hilar transection. A U tube, which consists of a single straight drain with multiple side holes and two percutaneous exits, essentially serves the combined functions of a PTBD and a biloma drain. It has the advantage of being more secure than either a PTBD or a biloma drain and requires the use of only one drainage bag. Patients with a common duct or hilar transection generally require the initial placement of a biloma drain, which is subsequently used in the process of U-tube placement after the biloma has had sufficient time to collapse around the drain.

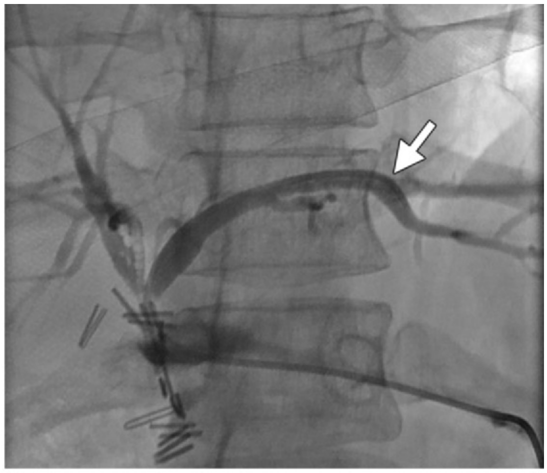
In one approach, U-tube placement is accomplished at PTC by first threading a guidewire and catheter through the site of duct injury, into the biloma. The wire then can be snared through the preexisting biloma drainage tract to create through-and-through access, allowing placement of a straight drainage catheter with two percutaneous exits and multiple side holes (Fig 17) (23).

In another approach to U-tube placement, a contrast medium is first injected into a preexisting biloma drainage catheter to attempt retrograde opacification of the bile ducts through the site of bile duct transection. Opacification is most likely to be adequate when the biloma has undergone sufficient drainage to allow the biloma cavity to collapse around the catheter (23). A catheter and wire are then threaded through the biloma tract and across the leakage site in the bile duct. A snare is inserted through the catheter and serves as a target for the fluoroscopically guided transhepatic insertion of a 21-gauge needle and wire. The wire is snared to create through-and-through access allowing placement of a straight drain (Fig 18) (22,23). As mentioned previously, injection of contrast material into a biloma should not be performed in patients with signs and symptoms of infection.

Figure 18. Fluoroscopically guided U-tube placement in a 25-year-old woman with a large perihepatic biloma due to a hilar injury from laparoscopic cholecystectomy. **(a)** Image obtained after the injection of contrast medium into a previously placed biloma drain demonstrates retrograde opacification of the left bile ducts via the leakage site (arrow). **(b)** Image shows a catheter that was inserted into the biloma drainage tract and manipulated across the leakage site, into the left hepatic duct (arrow). **(c)** Image shows a snare inserted through the catheter into the left hepatic duct. **(d)** Image shows a needle being advanced toward the snare. The depth of the needle was confirmed by angling the x-ray tube. **(e)** Image shows a wire inserted through the needle and snared to create through-and-through access allowing placement of a straight drain (arrowheads).



a.



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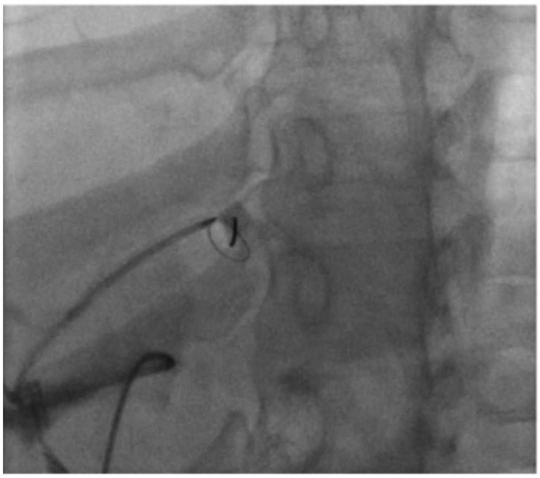

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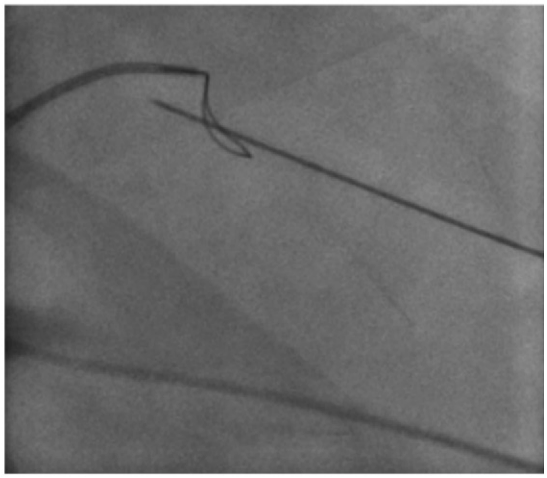

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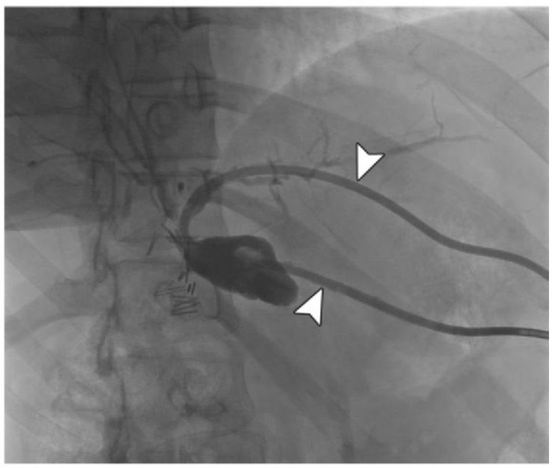

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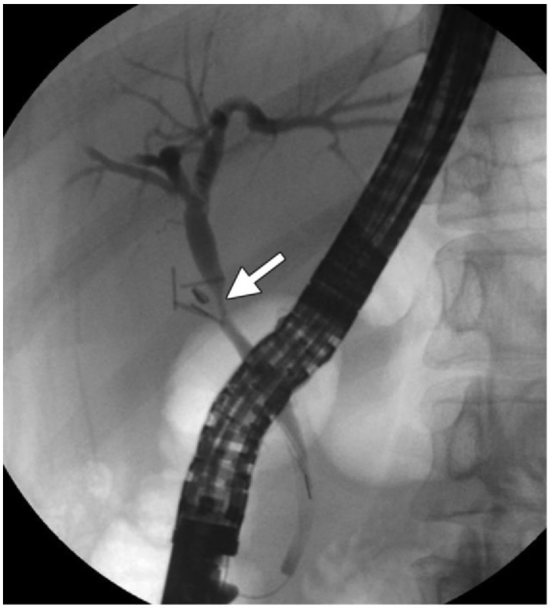

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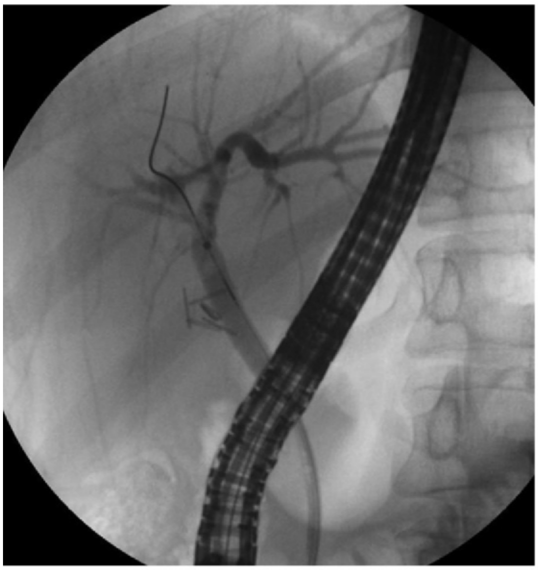

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Figure 19. Stricture of the common hepatic duct in a 24-year-old woman after laparoscopic cholecystectomy. **(a)** ERCP image shows a high-grade stricture of the distal common hepatic duct (arrow). **(b)** ERCP image shows treatment of the stricture with stent placement and balloon dilation, which was performed three times over 5 months. **(c)** Final ERCP image depicts a minimal residual stenosis of the common hepatic duct (arrow). The patient remained asymptomatic, with normal levels of alkaline phosphatase and bilirubin.

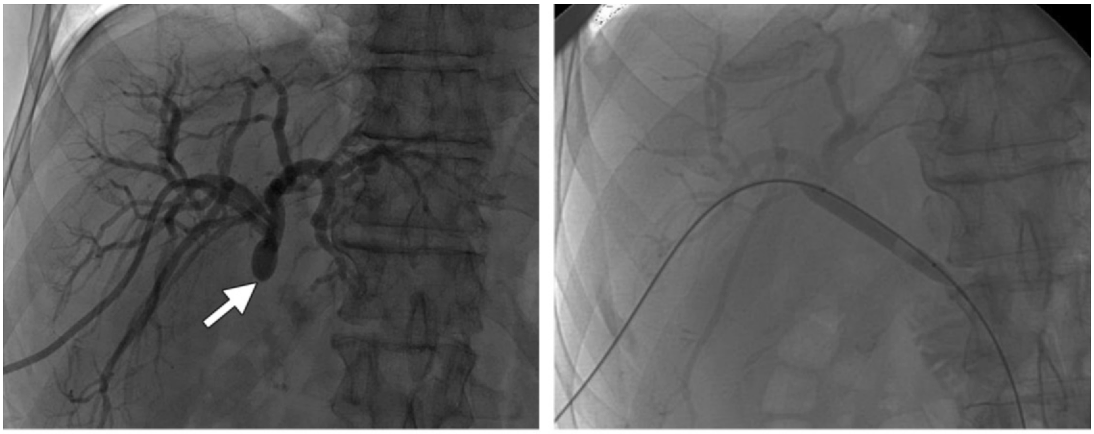
Benign Biliary Strictures

Approximately 95% of biliary strictures are secondary to biliary tract surgery (31). Initial management of bile duct strictures is focused on reestablishing biliary drainage to relieve obstructive jaundice, cholangitis, or both (23,32). Biliary-enteric continuity is a prerequisite for nonsurgical management with either a percutaneous or an endoscopic approach. Endoscopic stent placement and balloon dilation are generally the first-line treatments in patients with a common duct stricture who do not have a surgically created biliary-enteric anastomosis (Fig 19) (33). Reported success rates for endoscopic intervention vary widely, from 27% to 89% (33).

Strictures of the proximal bile ducts and strictures that develop after surgical reconstruction of the bile ducts can be treated percutaneously (Fig 20). There is no general consensus about the technical aspects of percutaneous procedures, such as the optimal duration, frequency, or number of balloon dilations; the type of balloon that should be used; or the best use of stents (34).

The success or failure of treatment is determined on the basis of the cholangiographic appearance of the ducts and various clinical measures. Saad (34) considers treatment of anastomotic strictures to be technically successful

Figure 20. Percutaneous treatment of anastomotic stricture in a 65-year-old man with cholangitis 2 years after a Whipple procedure for removal of an intraductal papillary mucinous neoplasm, which was found to be benign. **(a)** Initial PTC image demonstrates bile duct dilatation and nearly complete occlusion at the choledochojejunal anastomosis (arrow), with only a minimal amount of contrast material passing into the jejunum. An external drain was placed. **(b)** After a period of biliary decompression, a wire was successfully passed through the stricture, and balloon dilation of the stricture was performed. **(c)** Cholangiogram obtained after multiple sessions of dilation shows decreased stenosis (arrow). Subsequent dilation sessions brought no further improvement. The patient was released with a small-caliber catheter left in place to maintain percutaneous access, and his alkaline phosphatase and bilirubin levels were monitored over the next 4 weeks. He remained asymptomatic, with no abnormal findings in liver function tests, and the catheter was removed.



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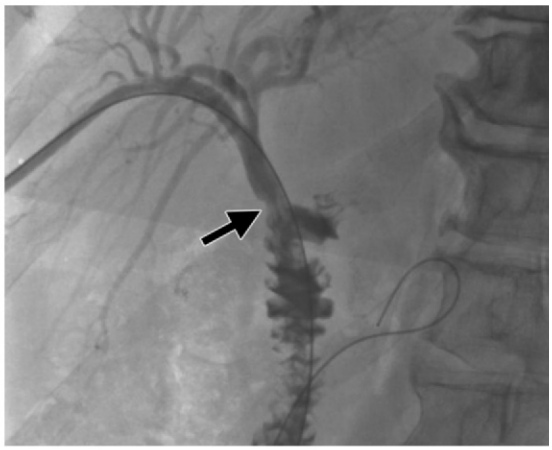


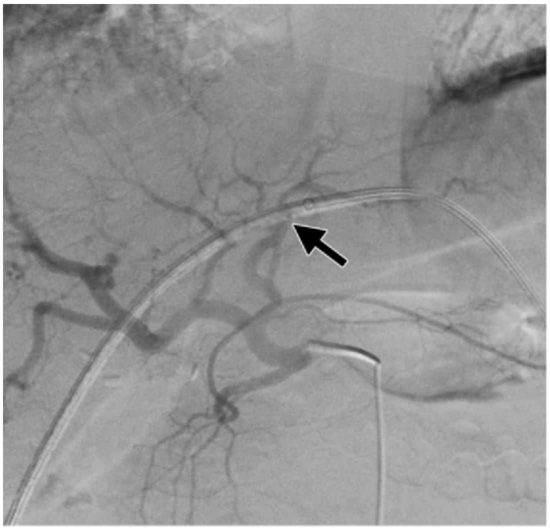
c.

when there is residual stenosis of 30% or less in the normal diameter of the duct and considers it to have failed when the desired effect is not achieved after three sessions of balloon dilation or when no improvement is achieved after any single session. Between sessions of balloon dilation, an internal-external biliary catheter is placed in the duct to prevent its relapse into stricture. The optimal duration of biliary catheterization remains to be determined, but existing data indicate that a duration of more than 4 months is associated with improved ductal patency (32). After a technically successful treatment regimen, the biliary catheter is externalized (placed proximal to the site of previous stricture) and capped. If the patient remains asymptomatic and laboratory test results are not suggestive of biliary obstruction, the catheter is removed (34). Long-term ductal patency after percutaneous treatment alone has been reported in 33%–90% of cases (33,34).

Complications of Percutaneous Interventions

Complications of percutaneous interventions can be categorized as major or minor (Table 3) (24,35). The average rate of major complications for PTC is 2%, and that for PTBD placement is 2.5% (24). Many complications are preventable with careful planning and attention to detail (35). Some complications can be treated with interventional procedures.

The risk of arterial and major venous hemobilia can be minimized by avoiding the central ducts when placing biliary drains (35,36). Because there is a higher incidence of arterial hemobilia with left-sided PTBD placement, right-sided PTBD placement may be preferable when a left-sided approach is not required (37). A venous source of hemobilia is more common overall; however, in a hemodynamically unstable patient or a patient with pulsatile bleeding from within or around a biliary drainage catheter, the interventional radiologist should proceed directly to hepatic arteriography to allow embolization of an arterial source of bleeding (Fig 21) (36).



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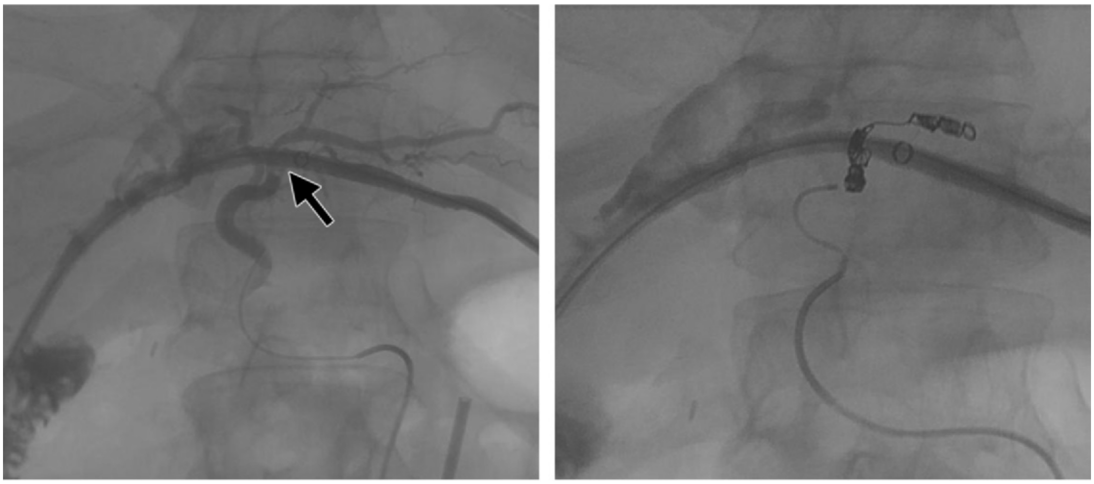
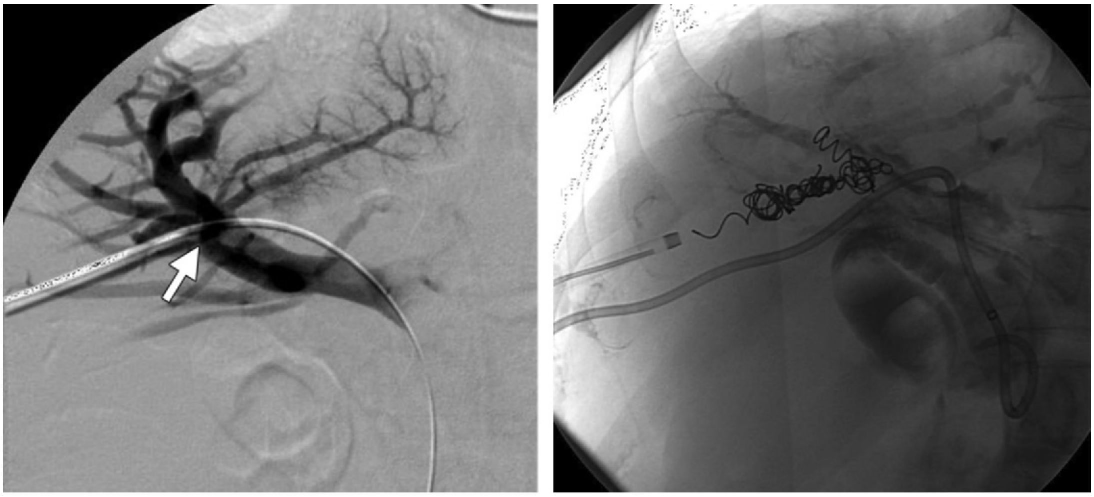


b. c.

Figure 21. Hemobilia 1 week after placement of an internal-external biliary drain for treatment of cholangitis due to anastomotic stricture in a 34-year-old man with a history of hepaticojejunostomy. Pulsatile bleeding was seen when removal of the drain was attempted over a wire. **(a)** Hepatic arteriogram shows evidence of transgression of a branch of the left hepatic artery near the drain entry site in the left hepatic duct (arrow). **(b)** Fluoroscopic image shows opacification of the left hepatic arterial branches by contrast material injected through the drain, allowing identification of the site of arterial transgression (arrow). **(c)** Fluoroscopic image shows successful coil embolization of the transgressed left hepatic arterial branch.

Table 3
Complications of Percutaneous Biliary Interventions

Major complications
Sepsis
Cholangitis
Bile leakage
Major venous and arterial hemobilia
Hemoperitoneum and subcapsular liver hematoma
Pleural complications (ie, pneumothorax, hemothorax, bilious effusion)
Death
Minor complications
Pain
Minor bleeding
Bacteremia
Transient hyperamylasemia



a. b.

Figure 22. Hemobilia soon after placement of a biliary drain in a 78-year-old man with cholelithiasis and jaundice. **(a)** Fluoroscopic image obtained after contrast medium was injected into the sheath as it was withdrawn through the biliary drainage tract shows opacification of the right portal vein (arrow) due to transgression during drain placement; no contrast material flows into the bile ducts with the sheath in this position. **(b)** Fluoroscopic image shows a newly placed internal-external drain in a more peripheral bile duct, adjacent to the original drainage tract. The site of venous transgression has been successfully occluded with multiple coils.

In a hemodynamically stable patient with hemobilia, tractography is generally the first diagnostic test performed to determine the source of bleeding, which is most commonly a portal vein. This test is performed by exchanging the catheter for a sheath and injecting contrast material through the sidearm of the sheath during fluoroscopy while slowly withdrawing the sheath over the wire. If a venous source is identified, a large-diameter drain may be substituted and capped for 1 or 2 days to tamponade the bleeding. Alternatively, if these measures fail or if a large portal vein has been transgressed, the transhepatic drain can be relocated, and coil embolization of the old drainage tract can be performed (Fig 22) (35,36).

Surgical Treatment of Bile Duct Injuries

Teaching Point

Injuries that cannot be definitively treated with percutaneous or endoscopic techniques require surgical repair. These include large lateral defects in major ducts, strictures refractory to percutaneous or endoscopic treatment, and nearly all complete transections and ligations. Roux-en-Y hepaticojejunostomy is the preferred procedure for most major bile duct injuries; it provides excellent long-term outcomes overall, with long-term patency in more than 90% of patients, when the procedure is performed by an experienced hepatobiliary surgeon (6,32,38). The importance of the timing of surgical repair for the outcome is controversial. In a retrospective analysis of factors associated with successful surgical reconstruction, it was found that eradication of intraabdominal infection (ie, drainage of all fluid collections), complete preoperative characterization of the bile duct injury with cholangiography, correct surgical technique, and repair by an experienced biliary surgeon were the most important variables, whereas the timing of reconstruction was not independently significant (39). More proximal injuries are associated with greater difficulty of surgical repair; however, it is unclear whether a more proximal level of injury is an independent predictor of outcome when the repair is performed by an experienced biliary surgeon (38,39). The most common long-term complication of Roux-en-Y hepaticojejunostomy is anastomotic stricture formation, which occurs in 10%–19% of patients, usually within 2 years after the procedure (38). Anastomotic strictures can be treated percutaneously, as described earlier (Fig 20). In one study, the overall patency rate with a management strategy of initial percutaneous treatment followed by surgical reconstruction in patients in whom percutaneous treatment failed was 98% at a mean follow-up interval of 76 months (32).

It should be noted that biliary reconstruction is a challenging surgical procedure even in the hands of experienced hepatobiliary surgeons. There is substantial potential for morbidity and mortality, which are estimated at 38%–47% and 2%–9%, respectively (38). When iatrogenic injuries are repaired by the surgeon who created the injury, morbidity and mortality are higher and long-term outcomes are generally poor (3,6). These data underscore the value of endoscopic and percutaneous management techniques, particularly when experienced hepatobiliary surgeons are not available and in patients who are poor candidates for surgery.

Conclusions

Iatrogenic bile duct injuries present complex problems that require a multidisciplinary approach for their optimal management. Imaging is key for characterizing the injury and planning percutaneous and surgical treatment procedures. Initial damage control with percutaneous drainage of fluid collections and reestablishment of normal biliary drainage is of the utmost importance to achieve a successful outcome. Percutaneous and endoscopic procedures allow definitive treatment of certain types of injuries and may be the only options for treating injuries in patients who are poor surgical candidates. Most major bile duct injuries ultimately require surgical biliary reconstruction, which provides excellent long-term outcomes overall, particularly when combined with percutaneous interventions to optimize the patient's condition preoperatively and to manage postoperative complications.

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Management of Iatrogenic Bile Duct Injuries: Role of the Interventional Radiologist

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Imaging is vital for establishing the diagnosis, delineating the extent of injury, and planning appropriate intervention. Optional imaging modalities include cholescintigraphy, computed tomography (CT), ultrasonography (US), magnetic resonance cholangiopancreatography (MRCP), endoscopic retrograde cholangiopancreatography (ERCP), percutaneous transhepatic cholangiography (PTC), and fluoroscopy with injection of a contrast medium via a surgically or percutaneously placed catheter with bilious drainage due to a bile leak.

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Initial management of bile duct injuries is focused on stabilizing the patient's status, draining bilomas and abscesses, establishing biliary drainage, and obtaining a complete cholangiographic characterization of the injury.

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Fluid collections that are known or suspected to contain bile should be drained promptly; delayed drainage is associated with an increased incidence of serious complications, such as abscess formation, cholangitis, and sepsis.

Page 123

Complete ductal ligation or transection, proximal duct injury, and transection or ligation of an aberrant right hepatic bile duct usually require PTC with PTBD placement for biliary decompression, diversion, or both.

Page 132

Injuries that cannot be definitively treated with percutaneous or endoscopic techniques require surgical repair. These include large lateral defects in major ducts, strictures refractory to percutaneous or endoscopic treatment, and nearly all complete transections and ligations.