OVERVIEW

Minimally invasive techniques to manage biliary pathology have reduced the need for open operative intervention. Although open exploration for biliary disease has become less common, specific situations, such as obstructive common duct stones not amenable to endoscopic therapy or restoration of biliary-enteric continuity following resection of bile duct tumors, remain indications for more invasive approaches. It is important to have a thorough understanding of biliary anatomy and familiarity with various options for operative exposure and management. Operative techniques encompassing bile duct exploration and biliary-enteric bypass will be the focus of this chapter.

ANATOMY

Knowledge of extrahepatic biliary anatomy and an appreciation of anatomic variants are essential for safe operative conduct (see Chapter 2). The intrahepatic bile ducts draining the various sectors ultimately coalesce into the right hepatic duct draining the right hemiliver and the left hepatic duct draining the left hemiliver, which then converge at the liver hilum to form the common hepatic duct, the most anterior structure of the portal triad at this location. In approximately 80% to 90% of cases, the right hepatic artery courses posterior to the common hepatic duct, whereas in the minority of cases, it can be found anterior to the duct. The right hepatic duct assumes a longer extrahepatic course with a transverse orientation as opposed to a shorter and more oblique orientation when segment IVB is narrow (Fig. 31.1). The left hepatic duct and left portal vein travel within a peritoneal reflection of the gastrohepatic ligament; exposure of these structures is facilitated by lowering the hilar plate at the base of segment IVB (Fig. 31.2). As the left hepatic duct and left portal vein enter the umbilical fissure, they are joined by the left hepatic artery, and vascular branches to segments II, III, and IV travel with biliary drainage from these segments. To maximize access to these structures, a bridge of hepatic tissue at the base of the umbilical fissure (bridging segment III and IV) must often be divided (Fig. 31.3). The ligamentum teres (obliterated umbilical vein) at the base of the falciform ligament runs across the umbilical fissure, separating segment IV from segment II and III. Segment I hepatic ducts flow into both the right and left biliary systems, with the majority of drainage entering the left hepatic duct just proximal to common hepatic duct.

Safe operative conduct requires a close familiarity with anatomic variations of biliary drainage, as they occur in up to 25% of patients (Babel et al, 2009) (see Chapter 2). There are a number of ductal anomalies related to the convergence of the left and right hepatic ducts and the insertion of cystic duct. Although the left biliary system is fairly consistent, the right biliary system is prone to anatomic variation; the most common variants include the right anterior or posterior sector ducts traversing a longer extrahepatic course before joining the left biliary system (Blumgart et al, 1984).

BILE DUCT EXPLORATION

Overview

It is estimated that approximately 10% of the adult U.S. population is affected by cholelithiasis, with nearly one third of these patients requiring cholecystectomy over their lifetime (see Chapter 32). Approximately 10% to 15% of patients undergoing cholecystectomy have choledocholithiasis; thus common bile duct (CBD) stones remain the most common etiology for biliary exploration (Costi et al, 2014) (see Chapters 36 and 37). There are a number of techniques available for evaluation and clearance of the common bile duct, including percutaneous, endoscopic, laparoscopic, and open methods. Open common bile duct exploration (CBDE) is only necessary in a small subset of patients. This subset includes patients undergoing an open cholecystectomy (or a laparoscopic cholecystectomy converted to open) in which choledocholithiasis is suspected, patients with large or multiple stones, and patients requiring transduodenal sphincteroplasty. Although it is more invasive, open CBDE is highly effective and safe. A recent analysis demonstrated equivalent duct clearance, morbidity, and mortality between endoscopic measures and open surgical techniques (Clayton et al, 2006). Because percutaneous, endoscopic, and laparoscopic modalities are discussed in other chapters, open bile duct exploration will be the focus of the next section.

Incision and Exposure

A right subcostal incision affords satisfactory exposure of the gallbladder, portal structures, and duodenum; alternatively, an upper midline incision may be equally effective, particularly in thin patients. Division of the lateral peritoneal attachments of the right colon, followed by mobilization of transverse colon mesentery off of the duodenum, provides visualization of the duodenum. A generous Kocher maneuver facilitates access to the CBD located in the lateral border of the hepatoduodenal ligament. Cephalad retraction of the undersurface of the liver at the base of segment IVB will optimize visualization of the extrahepatic biliary system (Fig. 31.4). Additionally, cholecystectomy can enhance exposure of the hepatoduodenal ligament and can facilitate intraoperative transcystic cholangiography, which can help to delineate biliary anatomy. Dissection of the gallbladder and cystic duct also identifies the confluence of
Cystic duct and CBD. Once the CBD has been successfully identified, the overlying peritoneal tissue can be dissected free to allow access to the anterior portion of the duct.

**Supraduodenal Exploration**

The anterior aspect of the CBD is exposed, and two stay sutures are placed on either side of the midpoint of the planned longitudinal incision. The choledochotomy should be located anteriorly to avoid compromising blood vessels that typically run along the medial and lateral aspects of the CBD and common hepatic duct. To avoid injury to the cystic duct, the site of cystic duct insertion should be identified, as this may occur in a medial or posterior location. During the incision, caution should be taken to avoid injuring the posterior wall of the duct. The length of the choledochotomy will depend upon the diameter of the duct and size of stones present with the lumen but is generally 1 to 2 cm. Another consideration regarding the location of this incision is proximity to duodenum; in the event that a choledochoduodenostomy should be required for appropriate drainage, every effort should be made to position the incision distally enough to permit a tension-free anastomosis to the proximal duodenum.
After choledochotomy, flushing of the duct (distally toward the ampulla) with saline irrigation can result in expulsion of stones. Following this, a deflated Fogarty balloon catheter is passed distally through the ampulla into the duodenum. Once the tip of the catheter is palpated within the duodenal lumen, the balloon is inflated and the catheter is withdrawn until resistance is encountered, indicating that the balloon is positioned against the sphincter of Oddi. The balloon is slowly and partially deflated while applying continuous tension, allowing passage into the distal CBD. At this point, the balloon is carefully inflated, and the catheter is swept proximally, sweeping retained stones up toward the choledochotomy. This process is repeated until no stones return. The catheter is then passed proximally to retrieve any stones within the common hepatic duct and intrahepatic biliary tree. Rigid instruments such as clamps or stone forceps can cause injury to the bile duct and are therefore generally best avoided. Rather, a choledochoscope can be utilized to visualize remnant stones. These can be captured with basket retrieval, in which the basket is passed beyond the stone, opened, and pulled back to ensnare the stone. The choledochoscope and associated basket with stone are then withdrawn. At the conclusion of duct exploration, confirmation of proximal and distal duct clearance is performed either using choledochoscopy or completion cholangiography (Verbese\ et al, 2008).

Transduodenal Exploration

When an impacted stone at the distal CBD cannot be cleared via choledochotomy, a transduodenal approach can be used. A 2- to 4-cm longitudinal incision on the lateral aspect of the second portion of the duodenum can allow visualization of the ampulla. Stay sutures are placed on either side of the incision to maximize exposure. If there is difficulty visualizing the ampulla, a small catheter can be passed through the choledochotomy into the duodenum. A sphincterotomy is performed at the 10 to 11 o’clock position, and the sphincter is incised to the level of the impacted stone or probe (catheter). Placing the incision at this location in the ampulla minimizes the chance of pancreatic duct injury, which is generally located opposite the planned sphincterotomy site. The stone is then extracted, and the CBD mucosa is approximated to the duodenal mucosa with absorbable sutures (sphincteroplasty) to avoid postoperative papillary stenosis. Once again, a catheter is passed to ensure resolution of obstruction, and choledochoscopy or cholangiography is used to confirm the absence of residual stones. The duodenotomy is typically closed in one layer (Verbese\ et al, 2008). If sphincteroplasty is not successful, the obstruction can be bypassed with a choledochoduodenostomy (discussed in Choledocho-duodenostomy later).

T-Tubes

Although T-tube insertion for choledochotomy closure is not mandatory, advantages include drainage of bile in the setting of CBD or papillary edema and access for postoperative stone retrieval or cholangiography or choledochoscopy. Disadvantages include tube migration, obstruction, and bile leak following removal. Although closure over a T-tube is typically the preferred approach, a recent analysis suggested that the duct can be closed primarily without increased morbidity or mortality (Gurusamy et al, 2013). If a T-tube is used, size 14 Fr or larger will permit cholangiography and choledochoscopy. The T-tube is prepared by cutting two limbs at lengths that will not traverse into the left or right hepatic duct proximally or into the duodenum distally, and by excising the back wall of the horizontal portion of the T (to minimize the risk of tube occlusion and to facilitate tube removal). The tube is inserted through the choledochotomy, and the remainder of the duct is closed with fine absorbable sutures around the tube. Care should be taken to leave enough redundancy in the intraperitoneal portion of the tube to avoid tension (and possible tube dislodgement) in the event of significant postoperative abdominal distension. Postoperatively, the T-tube is placed to dependent drainage until resolution of postoperative papillary edema allows physiologic flow of bile into the duodenum. If persistently elevated output or drainage around the tube occurs, investigation via cholangiography can identify malfunction, dislodgement, or distal obstruction secondary to retained stone. If a repeat cholangiogram at approximately 2 to 3 weeks is normal, the T-tube may be removed. If choledocholithiasis persists, the T-tube can be clamped to promote stone passage. If signs or symptoms of cholangitis occur, the tube can be unclamped and repeat imaging is obtained. Residual obstruction may be amenable to stone extraction via T-tube or endoscopic or percutaneous access.

Outcomes

Open CBDE has been shown to be a safe procedure, with favorable mortality and morbidity rates. A recent analysis of multiple trials comparing open CBDE with endoscopic retrograde cholangiopancreatography (ERCP) identified similar rates of mortality (1% vs. 3%) and morbidity (20% vs. 19%) in the open surgery versus endoscopy groups, respectively (Dasari et al, 2013). Even in high-risk patients, open surgical intervention has comparable mortality (4% vs. 6%) and morbidity (23% vs. 16%) versus ERCP (Targarona et al, 1996). The rate of retained stones was historically lower after open CBD exploration than after ERCP (6% vs. 20%) (Suc et al, 1998). However, more recently, studies have demonstrated rates of retained stones after ERCP to be approximately 2% to 10%, although higher rates are reported for difficult scenarios (i.e., larger stones, cholangitis) (Rogers et al, 2010; Wan et al, 2011) (see Chapter 29). For instance, a recent study of retained stones after ERCP in a high-volume center demonstrated clearance of the CBD in 91.7% of patients with stones less than 2 cm in diameter versus 77.8% successful clearance in patients with stones greater than 2 cm in diameter (Wan et al, 2011). There is a relative paucity of recent data encompassing open CBDE due to options of ERCP and laparoscopic CBDE. However, given the safety profile and necessity when less invasive alternatives fail, open CBDE remains an important option for CBD stones.

BILIARY-ENTERIC ANASTOMOSIS

Overview

There are three key aspects to consider when planning a biliary-enteric anastomosis (see Chapter 42). These include identification of a healthy segment of bile duct tissue proximal to the site of obstruction; preparation of a segment of alimentary tract such as duodenum or, more commonly, Roux-en-Y jejunal limb; and construction of a mucosa-to-mucosa anastomosis. It is therefore important to use preoperative imaging to clearly delineate the biliary anatomy prior to undertaking operative intervention for biliary decompression. It should be noted that invasive
cholangiography is no longer necessary to delineate biliary anatomy in the great majority of cases. Cross-sectional imaging with magnetic resonance imaging/magnetic resonance cholangiopancreatography, or even thin-cut computed tomography scans, can accurately characterize the anatomy of the biliary tree and underlying pathology (see Chapter 19). Invasive imaging of the biliary tree with endoscopic or percutaneous cholangiography allows stent placement, which can facilitate intraoperative identification of right and left hepatic ducts (see Chapters 20, 29, and 30). However, it should be stressed that utilization of an intrabiliary catheter should not be necessary in most cases for duct identification in the hands of an experienced biliary surgeon. It is also important to recognize that instrumentation of the biliary tree introduces bacterial contamination that, in a setting of biliary stasis, can result in cholangitis, periductal inflammation, and a higher risk of postoperative infections. Caution must also be exercised to avoid percutaneous drainage if it is unlikely that the stent can be passed across the obstructing lesion. Insertion of a percutaneous drain into an excluded biliary segment will result in bacterial colonization of static bile; if that hepatic segment cannot be decompressed by a subsequent operative intervention, it will not be possible to remove that external drain without risking refractory cholangitis. These complexities underscore the critical importance of an experienced multidisciplinary team reviewing and treating complex biliary obstruction, particularly at the biliary confluence.

Depending on the underlying pathology, there are a number of options for restoration of biliary continuity with the alimentary tract. For instance, choledocholithiasis refractory to local exploration may require choledochoduodenostomy. Other benign etiologies, such as iatrogenic bile duct injury, strictures from previous biliary-enteric operations, choledochal cysts, or inflammatory strictures, may require restoration with Roux-en-Y choledochojejunostomy or hepatojejunostomy. Additionally, benign proximal biliary strictures as well as malignancy (cholangiocarcinoma) may require anastomosis between intrahepatic ducts and jejunum. Finally, the gallbladder may also be utilized to facilitate drainage (cholecystoduodenostomy and cholecystojejunostomy). Although nonoperative measures can be utilized in most situations, familiarity with the various surgical techniques can enable appropriate restoration of biliary-enteric continuity when the situation demands (see Chapter 42).

**Incision and Exposure**

A right subcostal incision with or without an upper midline extension or a left subcostal extension followed by upward elevation and cephalad retraction of the costal margin provides adequate exposure for construction of any biliary-enteric anastomosis. The ligamentum teres is ligated and divided, and the falciform ligament is divided to its most cephalad extent on the diaphragm. Retraction of the ligamentum teres is helpful for optimal visualization of the vascular inflow and biliary drainage of segments II, III, and IV. If direct decompression of the gallbladder is not to be undertaken, cholecystectomy can be advantageous for identification of the cystic duct, which can be dissected to its point of insertion onto the common hepatic duct. Cholecystectomy will also expose the cystic plate, which runs in continuity with the hilar plate. By lowering the hilar plate, the left hepatic duct may be exposed as it runs against the base of segment IVB (Blumgart, 1987). Mobilization of the right colon with caudal retraction, followed by generous Kocher maneuver, will further enhance exposure for biliary-enteric bypass.

Caution must be exercised in the setting of long-standing biliary obstruction or conditions associated with ipsilateral hepatic atrophy and contralateral hypertrophy. In the scenario of marked right hemiliver atrophy, the liver hilum and portal structures will become rotated in a counterclockwise manner. Consequently, the portal vein will assume a more anterior location, and the CBD or common hepatic duct will be posteriorly displaced. Hypertrophy of segment IV protrudes over the porta hepatis and may provide additional complexity for access to the hilum and left biliary system (Pottakkat et al, 2009). In cases of very profound right liver atrophy, access to the biliary confluence may require a thoracoabdominal incision.

**Hepatocjejunostomy**

Despite the need for an additional anastomosis (at the jejunoojejunostomy), Roux-en-Y hepatocjejunostomy is the most common surgical reconstruction for biliary obstruction. The jejunum is typically anastomosed to the common hepatic duct just distal to the confluence of the right and left hepatic ducts. If this approach is not feasible due to tumor infiltration or a high stricture, drainage can be obtained via the right hepatic duct or left hepatic duct. Moreover, ducts draining segment III can be utilized when the left hepatic duct is not accessible (Blumgart et al, 1984). Disadvantages include necessity for two anastomoses and exclusion of bile from the duodenum.

**Approach to Right Hepatic Duct**

As the portal pedicles enter the liver parenchyma, they remain enclosed within a fibrous sheath derived from Glisson’s capsule. Access to the right portal pedicle containing the right hepatic duct can be achieved by isolating the pedicle in an extrahepatic location or by exposing the pedicle via intrahepatic dissection. The extrahepatic approach begins by lowering the hilar plate; the peritoneum along the posterior aspect of segment IV is divided, allowing separation of Glisson’s capsule from the peritoneal reflection enveloping the porta hepatis. By reflecting the base of segment IV in a cephalad direction, this dissection effectively exposes the confluence of the right and left hepatic duct. By continuing this plane of dissection to the right (onto the cystic plate), the right hepatic duct may be exposed (Strasberg et al, 2008). If the extrahepatic portion of the right hepatic duct is too short to be visualized in this way (as is often the case), the intrahepatic approach may be used. This requires hepatotomies in the caudate process just posterior to the porta hepatis and along the base of the gallbladder fossa. A blunt right angle clamp may be passed between these hepatotomies to encircle the right pedicle, which can then be delivered for further dissection to identify the right hepatic duct, or the anterior or posterior sectional ducts (Fig. 31.5) (Jamieson & Launois, 1992).

**Approach to Left Hepatic Duct**

The left hepatic duct traverses an extrahepatic course below segment IVB from the umbilical fissure to the porta hepatis. Because of its longer extrahepatic course, the left hepatic duct is the preferred target. After ligation of the ligamentum teres with a firm tie, retraction is applied to elevate the left hemiliver. The bridge of tissue at the base of the umbilical fissure contains no large vessels and can be divided to provide mobility of the
FIGURE 31.5. A, Exposure of the right hepatic pedicle in the setting of a cholangiocarcinoma, extending into the left hepatic duct. Intrahepatic exposure of the right hepatic duct is accomplished initially by controlling the right portal pedicle. After performing hepatotomies in the caudate process just posterior to the porta hepatis and along the base of the gallbladder fossa, a blunt right angle can be used to facilitate encircling and delivery of the right pedicle. The overlying hepatic parenchyma is further dissected, which allows identification of the right hepatic duct, as well as the anterior or posterior sectional ducts. B, The relevant duct, usually the anterior sectoral duct, is opened, and anastomosis is carried out.

Approach to Segment III Duct

The presence of a bulky unresectable tumor at the hepatic hilus may require construction of a more proximal anastomosis. This can be achieved by exposing the biliary drainage of the left hemiliver within the umbilical fissure (Blumgart, 1987; Jarnagin et al., 1998; Voyles et al., 1983). If the left hemiliver has not atrophied from long-standing biliary obstruction, unilateral left-sided biliary decompression will effectively relieve obstructive jaundice and restore hepatic function even when the biliary drainage of the excluded right hemiliver remains obstructed. In a series evaluating segment III bypass for malignant biliary obstruction, patients experienced durable relief of jaundice and pruritus; there was an 80% patency rate at 1 year (Jarnagin et al., 1998). Segment III bypass is best utilized in the setting of a dilated left biliary system, which facilitates identification of the segment III duct within the liver parenchyma; the procedure is much more challenging in the face of normal-caliber ducts. Also, it must be remembered that, if the right biliary system has been instrumented or is otherwise colonized and is isolated from the left hepatic duct, the segment III bypass approach will not provide adequate drainage.

After ligation and retraction of ligamentum teres, the band of liver parenchyma at the base of the ligamentum teres joining segment III and IVB (if present) is divided to enhance exposure of the segment III duct, which, if dilated, may be more readily apparent. This exposure can be facilitated by fashioning a superficial hepatotomy along the left of the ligamentum teres, through which the segment III duct may be exposed and opened without risk of injury to the vascular pedicle to segment III (Fig. 31.7). In circumstances where identification is difficult, localization can be confirmed by aspiration with a small-gauge needle. On occasion, a wedge resection of a portion of segment III can also be performed to provide exposure of the segment III duct (Fig. 31.8) (Blumgart, 1987). To prepare for biliary-enteric anastomosis, the duct should be dissected free for 1.5 cm but should not be cleared circumferentially. A defunctionalized jejunal loop is then brought up in a retrocolic fashion and prepared for anastomosis.
FIGURE 31.7. A, The liver is held up so that its inferior surface is seen. The bridge of liver between segment IV and the left lobe of the liver has been divided. The base of the ligamentum teres is seen. B, The ligamentum teres is then pulled downward. The peritoneum of its upper surface on the left side is incised, and the extensions passing into the liver are exposed. The left sides of these extensions are divided between ligatures, which must be passed carefully using aneurysm needles. This part of the dissection is tedious and should be carried out meticulously because hemorrhage within the recess adjacent to the segment III duct can be difficult to control. C, The segment III duct is exposed. D, The duct is opened longitudinally for anastomosis, which is carried out by the technique illustrated in Figure 31.13.

FIGURE 31.8. A, The liver is split to the left of the ligamentum teres in the umbilical fissure, and it may be necessary to remove a small wedge of liver tissue. B, The segment III duct is exposed at the base of the liver split above and behind its accompanying vein and is ready for anastomosis.
Chapter 31  Bile duct exploration and biliary-enteric anastomosis

Construction of Anastomosis

For the purposes of Roux-en-Y reconstruction, the most proximal loop of jejunum that can be brought to lie against the planned site of anastomosis without tension is selected. The jejunum is transected, and a Roux limb of 50 to 70 cm is passed in a retrocolic fashion through the avascular portion of the transverse mesocolon to the right of the middle colic artery. The jejunojejunostomy may be fashioned in a sutured or stapled manner. We do not typically use transanastomotic stent; however, if a stent is to be used, it is preferable to pass the stent through the cut hepatic duct prior to construction of the anastomosis. The stent may be affixed against the duct wall with a single 4-0 or 5-0 absorbable catgut suture that is tied on the outside of the duct wall (Fig. 31.9); this maneuver helps to avoid inadvertent dislodgment of the tube during placement of the anastomotic sutures. When more than one biliary duct orifice is present, it is preferable to create a single-duct orifice by approximating the two ducts with a single row of 4-0 or 5-0 absorbable sutures (Fig. 31.10).

The hepaticojejunostomy may be performed in an end-to-side or side-to-side anastomosis (see Chapter 42). For an end-to-side hepaticojejunostomy, the bile duct segment is transected, and an adjacent jejunotomy is fashioned at a safe distance from the mesenteric margin of the bowel approximately 2 cm from the staple line. The jejunotomy length should be shorter than the ductotomy, as the bowel is more pliable than the duct. An anterior row of full-thickness, single interrupted 4-0 or 5-0 absorbable sutures is placed in the bile duct, passed from inside to outside, and working from the patient’s left to right. The needles are retained, and the sutures are kept in order. A single full-thickness posterior row of interrupted 4-0 or 5-0 absorbable sutures is used to approximate the inferior edge of the biliary duct to the superior edge of the jejunal loop (Fig. 31.11).
of jejunum, also working from patient’s left to right. These sutures are tied and cut short except for the two corner sutures, which are secured with clamps. The previously placed row of anterior sutures is then used to complete the anastomosis. Each needle is passed through the jejunum, tied, and cut short; the corner stay sutures are then cut.

A side-to-side anastomosis may be appropriate in the setting of left hepatic duct or segment III duct hepaticojejunostomy (see Fig. 31.12). Additionally, benign strictures (e.g., iatrogenic) can be approached in this fashion. When decompression is undertaken at the level of the proximal hepatic duct, increased length may be achieved by extending the incision onto the left hepatic duct. A longitudinal ductomy of approximately 2.5 to 3.0 cm is performed, with a corresponding jejunojejunostomy on the antimesenteric border, 2 cm from the staple line. An anterior row of full-thickness, single interrupted 4-0 or 5-0 absorbable sutures, passed from outside to inside, are retracted to allow exposure for placement of the posterior row. Full-thickness, single interrupted 4-0 or 5-0 absorbable sutures approximate the inferior edge of the duct to the superior edge of jejunum. Following placement, the posterior row of sutures is tied with knots on the inside. Subsequently, the preplaced anterior row of sutures are used to complete the anastomosis; they are passed from inside to outside on the jejunum, and the knots are tied on the outside (Winslow et al, 2009).

**Choledochojejunostomy**

Decompression of the biliary tree utilizing the common hepatic or CBD is typically undertaken in the setting of distal obstruction. Impacted ampullary stone(s), iatrogenic injuries, stricture formation in which a more durable drainage procedure obstruction. Impacted ampullary stone(s), iatrogenic injuries, and periductal fibrosis may necessitate biliary bypass. For repeat stent placement or revisions.

Choledochojejunostomy can be performed as an end-to-side or side-to-side anastomosis. For the end-to-side technique, a cholecystectomy with cystic duct ligation is performed, followed by ligation of the CBD or common hepatic duct (hepaticojejunostomy) at the level of planned transection. The duct is opened at the level of the planned anastomosis, and the endobiliary stent, if present, is removed. If desired, bile cultures may also be collected at this time. The remainder of the CBD is transected, and the distal stump is oversewn with 3-0 absorbable suture. It is important to identify healthy, well-vascularized duct proximal to the level of injury or pathology to avoid ischemic stricture. Similarly, care should be taken to avoid excessive circumferential dissection of the duct, as this can compromise its blood supply. A 50- to 70-cm Roux-en-Y limb of jejunum is passed retrocolic and to the right of the middle colic vessels and positioned to reside adjacent to the proximal bile duct in a tension-free manner. The posterior wall of the duct is sutured to the jejunum with a running 3-0 or 4-0 absorbable suture. The tail of the suture and needle are left intact. A jejunotomy is fashioned along the duct, and single interrupted 3-0 or 4-0 absorbable sutures are used to approximate the jejunal mucosa to the duct mucosa with the knots tied on the inside of the lumen. The anterior portion of the anastomosis is then completed using the running suture used to construct the posterior row (Fig. 31.12). Due to the small lumen, the anastomosis is generally completed with a single layer to avoid narrowing. Placement of a sponge circumferentially around the anastomosis allows an intraoperative test to confirm absence of a large bile leak.

The alternative approach of constructing a side-to-side anastomosis offers the advantages of less devascularization, with the use of a nontransected duct, and preservation of biliary-duodenal continuity, in case future ERCP should be desirable (Winslow et al, 2009). To perform this anastomosis, the anterior surface of the duct is exposed and opened longitudinally for a distance of 2.5 to 3.0 cm, avoiding the medial and lateral locations of periductal vasculature. The biliary-enteric anastomosis can then be completed in a similar manner as described for side-to-side hepaticojejunostomy (see earlier). A single interrupted anterior (or right) row of sutures allows exposure for placement of the posterior (or left) row, approximating duct to jejunum, followed by completion of the anterior row (Winslow et al, 2009).

**Cholecdochoduodenostomy**

Although cholecdochoduodenostomy has the physiologic advantage of enabling bile flow into the duodenum, this procedure is effective only for distal strictures or impacted stone(s) in the distal CBD. After mobilization of hepatic flexure of the colon, a generous Kocher maneuver is performed to allow sufficient mobility of the duodenum to enable construction of a tension-free anastomosis. The gallbladder is removed and the cystic duct ligated. A 2.5- to 3.0-cm longitudinal incision is made on the anterior surface of the supraduodenal CBD. Corresponding, the duodenum adjacent to the CBD is incised longitudinally along its superior-lateral border (Fig. 31.13). This produces incisions that are perpendicular to one another (unlike the parallel configuration used during hepaticojejunostomy). As with the hepaticojejunostomy, the duodenotomy is generally shorter in length than the ductotomy. The anastomosis is then constructed in a manner that anastomoses the bile duct transversely to the longitudinally-oriented duodenotomy. Three corner 4-0 or 5-0 absorbable sutures are placed: The first two are positioned between the midpoints of the ductotomy and proximal and distal aspects of the duodenotomy, and the third is placed between the distal aspect of the CBD incision and midpoint of the superior lip of the duodenotomy. Traction on the three corner sutures reorients the distal portion of the ductotomy transversely, facilitating placement of the posterior row of absorbable sutures between the superior edge of the duodenotomy and the distal half of the CBD. Full-thickness sutures are made to approximate the ductal mucosa to duodenal mucosa. A fourth corner suture can then be placed between the proximal end of the ductotomy and the midpoint of the anterior duodenal wall. Retraction of this fourth corner suture tents the remaining anterior wall of the anastomosis forward, facilitating placement of the remaining anterior row of sutures (Fig. 31.14). As before, use of a single row of sutures minimizes the risk of anastomotic narrowing.

**Cholecystoduodenostomy and Cholecystojejunostomy**

Loss common approaches to biliary bypass are cholecystoduodenostomy or cholecystojejunostomy. The cholecystoenteric bypass is relatively easy to construct, but long-term patency rates are suboptimal compared with maneuvers that directly decompress the extrahepatic biliary ducts. As a result, use of cholecystoduodenostomy or cholecystojejunostomy is limited
FIGURE 31.12.  A, Technique for end-to-side anastomosis of the bile duct below the hilus to jejunum. I, A 3-0 Vicryl suture is used, and the serosa of the jejunum is sutured to the full thickness of the bile duct. II, This suture is developed as the posterior wall of the bile duct is attached to the jejunal serosa. The dotted line marks the point of incision in the jejunum, which is made after the posterior layer is attached. III, The suture is now developed either as a continuous or an interrupted suture on the anterior layer. The posterior layer of the jejunal mucosa is not sutured directly to the bile duct mucosa. Several interrupted sutures may be inserted before completing the anterior layer, however, to approximate the mucosa (inset). IV, The anastomosis is completed. The inset shows the posterior layer with mucosal apposition. B, Alternatively, the jejunum may be opened, and a mucosa-to-mucosa anastomosis may be performed with a continuous polydioxanone suture as illustrated.
FIGURE 31.13. After the gallbladder is removed, the common bile duct is removed through a conventional longitudinal incision following a Kocher incision (1), freeing the lateral duodenum around the common duct. Routine common duct exploration is carried out. If indications for a choledochoduodenostomy exist, the anastomosis is performed. The incision in the common duct (2) is extended to 2.5 cm by direct measurement. In almost all instances, the incision in the duct carries into the common hepatic duct. The incision in the postbulbar duodenum (3) is slightly smaller because the stoma in the duodenum stretches to approximate the choledochal incision.

FIGURE 31.14. A, Each side of the choledochoduodenostomy is bisected by a suture (A and B) of absorbable material (chromic catgut or polyglycolic acid) that passes from the end of the duodenal incision through the midpoint of the choledochal incision. Likewise, the duodenal incision is bisected by a suture through the posterior wall of the duodenal incision and the lower apex of the choledochal incision (C). These stitches convert part of the longitudinal choledochotomy incision into a transverse ostium. The lax approximation of the duodenal and choledochal incisions occurs, with the duodenum mobilized, by placing tension on a lateral stay suture (A or B) and the middle stay suture (C). B, Sutures may be placed to complete the posterior suture line, approximating the common bile duct to the posterior duodenal incision. After placement of the sutures, they are tied so that the knots are within the lumen. The anterior wall is similarly approximated using a suture bisecting the anterior duodenal incision (D) and through the original apex of the bile duct incision. C, With this bisecting suture (D) tented forward, each of the segments between the tied lateral stay suture and this anterior suture is similarly approximated using interrupted sutures with the knots tied on the outside. The anastomosis is completed by completing the third segment of this triangle with sutures placed (E) between the remaining lateral stay suture and the bisecting, anterior suture (D). It is important in the placement of these last sutures that they do not catch the posterior suture line. The benefit of placing all the sutures in one line of the triangular closure and tying them all after placement is that it allows an internal inspection before the lumen of the choledochoduodenostomy is obscured. A single row of sutures is all that is used. A second row would do nothing but decrease the choledochoduodenostomy orifice size and should be avoided. The sutures should be placed close enough for a bile-tight approximation. Digital pressure on the duodenum or the common duct should give no evidence of leakage. D, The completed anastomosis allows a thumb-sized defect to be palpated through the duodenal tongue that has been brought on to the common bile duct and common hepatic duct. The anastomosis may be drained or not, according to preference (the leak rate is 1%). The presence of a closed-suction drain (Jackson-Pratt type) obviates the need for a subsequent percutaneous drainage catheter if this uncommon complication occurs.
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FIGURE 31.15. Technique of cholecystojejunostomy. A, The cystic duct should join the common bile duct above the tumor. If it enters at the level of the tumor (dashed line), the procedure is contraindicated. B, The posterior layer of the anastomosis is performed with a running suture between the openings at the fundus of the gallbladder and the jejunum. C, The anterior layer of the side-to-side anastomosis is completed. (We do not use an associated enteroenterostomy.)

A  B  C

OUTCOMES

A recent single institution retrospective analysis of 45 patients undergoing reconstruction after biliary injury measured a postoperative biliary fistula rate of 3% and a biliary stricture rate of less than 5% over 4 years (Winslow et al, 2009) (see Chapter 42). Other analyses have also confirmed the safety and longevity of biliary decompression, with low rates of fistula and stricture formation necessitating subsequent operative intervention (Chapman et al, 1995; Jarnagin et al, 1998; Murr et al, 1999; Tocchi et al, 1996). Although the limited number of patients requiring biliary-enteric bypass prohibits

to circumstances of advanced malignancy that require simple operative interventions and only short-term palliation (Dayton, et al, 1980). Cholecystoenterostomy may be suitable in situations where major tumoral obstruction obscures access to the porta hepatitis; however, the obstruction must not extend to the level of the cystic duct insertion. The presence of cholelithiasis is another consideration, as significant stone burden within the gallbladder makes this operative strategy less attractive.

Operatively, the gallbladder and cystic duct are evaluated to ensure their suitability for biliary decompression; specifically, a patent cystic duct is required for this technique to provide effective drainage. To construct a cholecystoduodenostomy, a Kocher maneuver is used to provide enough duodenal mobility for a tension-free anastomosis. If cholecystojejunostomy is performed, the most proximal loop of jejunum that will easily lie adjacent to the gallbladder is selected; a Roux-en-Y is not routinely performed. The gallbladder fundus is secured to the antimesenteric border of duodenum or jejunum with interrupted 3-0 absorbable sutures. A cholecystotomy is performed and the gallbladder evacuated of stones and bile; a bile specimen can be sent for analysis. Continuity with the common hepatic duct is confirmed, and a corresponding enterotomy mirroring the cholecystotomy is fashioned. An anterior row of sutures is then placed to complete the anastomosis (Fig. 31.15).

OUTCOMES

A recent single institution retrospective analysis of 45 patients undergoing reconstruction after biliary injury measured a postoperative biliary fistula rate of 3% and a biliary stricture rate of less than 5% over 4 years (Winslow et al, 2009) (see Chapter 42). Other analyses have also confirmed the safety and longevity of biliary decompression, with low rates of fistula and stricture formation necessitating subsequent operative intervention (Chapman et al, 1995; Jarnagin et al, 1998; Murr et al, 1999; Tocchi et al, 1996). Although the limited number of patients requiring biliary-enteric bypass prohibits

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comparative analysis of the various techniques, the larger series demonstrate low perioperative morbidity and mortality and adequate long-term patency. In patients undergoing bypass for benign disease, consideration should be given to prolonged clinical monitoring, as there appears to be both a risk of delayed stricture and an elevated risk of cholangiocarcinoma. In a review of 1003 patients undergoing biliary decompression, cholangiocarcinoma developed in 5.8% of patients after transduodenal sphincteroplasty, 7.6% of patients after choledochoduodenostomy, and 1.9% of patients after hepaticojejunostomy after an interval of 132 to 218 months (Tocchi et al, 2001).

References are available at expertconsult.com.
REFERENCES
