
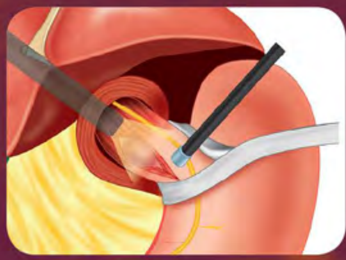

MINIMALLY INVASIVE SURGERY

LAPAROSCOPY, THERAPEUTIC ENDOSCOPY AND NOTES

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Chapter 4 Common bile duct exploration

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INTRODUCTION

Choledocholithiasis recognized prior to, during, or after cholecystectomy can often complicate the management of otherwise uncomplicated biliary pathology. Prior to 1987 and the introduction of laparoscopic cholecystectomy, open common bile duct (CBD) exploration in the setting of stones found at the time of cholecystectomy was the gold standard of management. Though often still necessary, the addition of specialty service adjuncts such as endoscopic retrograde cholangiopancreatography (ERCP) and percutaneous transhepatic cholangiography (PTC) to the surgeon's armamentarium has rapidly changed the initial management of choledocholithiasis. As surgical education has fervently embraced minimally invasive alternatives to almost all traditional open abdominal procedures, the shift to laparoscopic cholecystectomy as the standard approach to gallbladder disease has led to the use of laparoscopic common bile duct exploration (LCBDE) becoming more commonplace. In fact, the familiarity with open CBD exploration has waned and sometimes can be viewed as equally challenging as the laparoscopic approach.

INDICATIONS FOR INTRAOPERATIVE CHOLANGIOGRAM AND CBD EXPLORATION

The incidence of stone disease in the CBD in the setting of symptomatic cholelithiasis has been reported to be as high as 15–20% . Acceptance of such data has led many surgeons to advocate the performance of routine intraoperative cholangiography (IOC) at the time of cholecystectomy. Since its introduction almost 80 years ago, IOC has been reported to have reduced the incidence of unnecessary CBD explorations from 66% to less than 5%. Those who advocate its utility do so because there is evidence to suggest that the procedure (1) reduces the incidence, level, and severity of bile duct injuries, (2) serves as a prelude to intraoperative bile duct exploration, allowing a single stage procedure for the management of concomitant cholelithiasis and choledocholithiasis, (3) may eliminate the need for postoperative ERCP or endoscopic sphincterotomy (ES) in 1.4–3.4% of patients with abdominal pain or retained stones in the post-operative setting, and (4) is associated with a financial cost that is less than or equal to the cost of treating the bile duct injuries that are prevented by its use as well as the cost associated with diagnosis and management of those presenting with retained stones. Despite these arguments, the large number of laparoscopic cholecystectomies that are performed for symptomatic cholelithiasis and biliary dyskinesia without history or laboratory findings suggestive of choledocholithiasis, as well as the associated low incidence of retained stones in this patient population, continue to call into question the utility of performing routine IOC. As a consequence, practice patterns vary from institution to institution and surgeon to surgeon.

The indications for performing IOC at the time of cholecystectomy include: (1) history of elevated liver function tests, (2) history or presence of jaundice, (3) biliary pancreatitis, (4) radiographic evidence of a dilated ductal system, and (5) radiographic visualization of CBD stones. The presence of obstructive choledocholithiasis discovered during IOC for any of the above presentations warrants CBD exploration. A number of modalities are available to perform CBD exploration and will be discussed in the following section.

OPTIONS FOR CBD EXPLORATION

The current options for CBD exploration are as follows: (1) ERCP, (2) open common duct exploration, (3) laparoscopic common duct exploration, and (4) PTC.

Endoscopic retrograde cholangiopancreatography

The change in management of gallbladder disease from an open to a laparoscopic approach has increased surgeon reliance on their endoscopist colleagues to perform either preoperative or postoperative ERCP. This stems from the fact that although most general surgeons are adept at basic laparoscopy and performing laparoscopic cholecystectomy, many are not comfortable with advanced techniques such as laparoscopic CBD exploration.

The ERCP can be advantageous over the surgical approach in that it offers the facility to perform sphincterotomy, balloon dilatation of the major papilla, stenting, and in select cases, nasobiliary drainage. The literature supports performing preoperative ERCP in the following select patient populations: (1) those patients with high pre-operative serum bilirubin levels, (2) radiologic evidence of CBD dilatation on preoperative imaging (**Figure 4.1**), and (3) severe cholangitis. The indications for pre-operative ERCP in patients with gallstone pancreatitis remain more controversial. In the Japanese literature, e.g. guidelines have been published suggesting that ERCP is only necessary in patients in whom there is high suspicion of persistent obstruction of the CBD or associated severe cholangitis. The National Institutes of Health corroborate these guidelines noting that in those patients with a low pre-test probability of choledocholithiasis, pre-operative ERCP is not warranted. Further evidence supporting only selective use of pre-operative ERCP came from Chang et al. in a prospective randomized trial. Patients with mild to moderate gallstone pancreatitis (n = 59) were randomized into two arms: the first, receiving routine pre-operative ERCP and the second receiving post-operative ERCP only after an IOC demonstrated a stone in the CBD. They concluded that routine pre-operative ERCP was associated with longer mean hospital stay, greater cost, and no significant reduction in combined treatment failure rate when compared with selective post-operative ERCP.

When considering pre-operative ERCP, the inherent complications of the procedure must be weighed in the risk-benefit analysis.

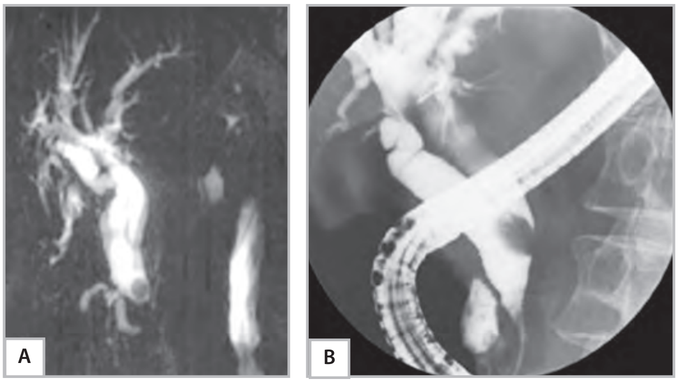

Figure 4.1 (A) Magnetic resonance cholangiopancreatography illustrating a stone in the distal CBD. A subsequent ERCP (B) verified the presence of a stone, and the patient underwent endoscopic stone retrieval and sphincterotomy. Reprinted from Surgical Clinics 88(6), Verbesy JE, Birkett BH, Common bile duct exploration for choledocholithiasis, pages 1315-1328, 2008, with permission from Elsevier Ltd.

Associated complications include: (1) acute pancreatitis, (2) sepsis, (3) hemorrhage, and (4) retroperitoneal duodenal perforation. Current literature cites an incidence of acute pancreatitis following ERCP ranging from 0.4–1.5% in those patients without sphincterotomy, and rising to upwards of 5.4% if a sphincterotomy is performed (Sekimoto 2006).

Open CBD exploration

Open CBD exploration was first described in 1889 by a New York surgeon, Robert Abbe. He described opening the duct of a 36-year-old woman with severe jaundice, removed an obstructive stone, and repaired the choledochotomy with fine silk relieving her affliction.

Though relatively rare in the modern era given the success of stone removal via ERCP or advanced laparoscopic technique, there are still indications which mandate an open approach to CBD exploration: (1) the patient with a complex surgical abdomen requiring open cholecystectomy with concomitant obstructive pathology, (2) a failed laparoscopic approach to stone retrieval, and (3) in the case of a surgeon not trained in advanced laparoscopic technique and without access to endoscopic services. A relative indication for open CBD exploration may be in the setting of a patient who requires a transduodenal sphincteroplasty.

Laparoscopic CBD exploration

In an era in which advanced laparoscopic skills are becoming more commonplace in the general surgeon's armamentarium, LCBDE has increasingly risen as a feasible option for CBD exploration. The advantages of LCBDE when compared to other therapeutic modalities include: (1) the ability to be performed at the same time as laparoscopic cholecystectomy sparing the patient a second intervention that requires further sedation, and at times, even general anesthesia, (2) avoidance of the potential complications of ERCP which as previously mentioned included pancreatitis, small bowel perforation, hemorrhage, and bacteremia/septicemia, (3) reduction in mean length of hospital stay, and (4) improvement of resource utilization.

With increasing healthcare budget limitations, careful consideration as to the economics of a chosen treatment modality must be observed. Several studies have sought to determine differences between LCBDE and ERCP with respect to resource utilization. In a review of data from the 2002 US National Inpatient Sample, Poulose et al. analyzed the results of a large patient cohort (n = 41,000), which underwent laparoscopic cholecystectomy in the presence of choledocholithiasis. The majority (93%) of these patients underwent ERCP to clear their CBD, whilst 7% underwent LCBDE. Mean hospital length of stay and charges were significantly decreased ($5000 and one less hospital day) in the LCBDE group. In a separate study corroborating these findings, selective LCBDE was compared with three other treatment modalities: routine preoperative ERCP, selective postoperative ERCP, and expectant management. In the final analysis, selective LCBDE was both more economically favorable and more successful in the prevention of retained choledocholithiasis than selective postoperative ERCP. Although there was no significant difference in the efficacy of preventing retained stones when LCBDE was compared to preoperative ERCP, the additional cost associated with the latter therapeutic option was prohibitive. In contrast however, intraoperative ERCP has been shown to clear the CBD with the same efficacy and cost-efficiency as LCBDE. Several studies have demonstrated no statistically significant difference with respect to surgical time, efficacy, number of stone extractions, post-operative complications, mean hospital stay and mean hospital charges between the two approaches. As most surgeons do not perform their own ERCP, the logistics required to coordinate services with endoscopic colleagues makes this modality difficult to incorporate into clinical practice. Finally, LCBDE obviates the potential procedural complications associated with ERCP and sphincterotomy such as acute pancreatitis, small bowel perforation, hemorrhage, bacteremia/septicemia, and bactobilia, which can lead to portal tract chronic inflammation. As such, although it requires a technical learning curve, LCBDE has proven to be an efficacious, economically feasible and viable therapeutic modality in the management of choledocholithiasis.

Percutaneous transhepatic cholangiography

In select patients, PTC may be necessary for CBD clearance, particulary when previous anatomic alteration prohibits an endoscopic approach. Access to the biliary system can be obtained percutaneously under ultrasound guidance. Via this access method, stones can be removed with or without performing retrograde sphincterotomy and lithotripsy also can be performed. A PTC drain (both external or external/internal) may then be utilized to decompress the biliary system between procedures or for temporary stenting after duct clearance.

OPERATIVE TECHNIQUES FOR CBD EXPLORATION

Open CBD exploration

Open CBD exploration begins by exposing the CBD in the free border of the lesser omentum above the duodenum. If this is difficult, as can be the case in a reoperative field with significant scar tissue, a small finder needle can be used to aspirate bile from the structure presumed to be the CBD. Once localized, two 4-0 chromic or PDS stay sutures are placed on either side of the planned choledochotomy site, and an anterior vertical incision is made, taking care not to injure the posterior aspect of the duct upon entrance into the duct lumen.

The first step in stone removal is to flush the duct with sterile saline. To do so, a red rubber catheter is placed distally in the duct through the choledochotomy. Small stones will often float back to the choledochotomy site and out. In the event that irrigant is not returning from of the incision, the red rubber should be pulled back as it is likely post-papillary.

If the flush method is unsuccessful, many surgeons will utilize a Fogarty balloon catheter to facilitate stone removal. The deflated balloon is passed through the choledochotomy site and into the duodenum. The balloon is then inflated and passed retrograde through the sphincter. It is pulled back through the choledochotomy site for stone retrieval. Care must be taken to not push any stones proximally into the CBD as the inflated balloon is extracted from the choledochotomy site. Finally, the catheter is then passed proximally to retrieve any proximal stones (**Figure 4.2**).

After flush and balloon catheter methodologies have been used, direct visualization of the duct lumen should be performed via cholodochoscopy. The flexible choledochoscope is advanced both distally and proximally through the choledochotomy. If a stone is present, a retrieval basket can then be passed via the instrument port of the scope past the visualized stone, opened, pulled back to grasp the stone and then closed under direct visualization. Rigid instrumentation is no longer recommended given its potential for damage to the CBD.

In rare instances, the aforementioned methodologies may still not prove to be successful for stone extraction. In these difficult situations, intracorporeal laser lithotripsy can be attempted under direct visualization. Following lithotripsy, the stone fragments are washed into the duodenum. Despite its potential for success, the technique is not commonly utilized as most practitioners have neither the appropriate training nor access to the required equipment.

In the worst-case scenario, if all of the above maneuvers fail, a transduodenal sphincterotoplasty can be performed. Following kocherization, the stone is manually palpated, and if not felt, a probe or balloon catheter can be inserted antegrade via the choledochotomy and passed into the duodenum to localize the sphincter. A 2–4 cm duodenotomy is then made in the anterolateral wall of the duodenum, and traction sutures are placed to evert the duodenal wall allowing better visualization of the ampulla. The sphincterotomy should be performed at the 10 o'clock position to avoid injury to the pancreatic duct, which normally sits in the 4 o'clock position, and is then matured with absorbable vicryl or PDS sutures (as nonabsorbable suture can be lithogenic), therby approximating the distal CBD to the duodenal mucosa. Patency can be confirmed by passing a balloon catheter antegrade or retrograde through the sphincter. The duodenotomy is then closed transversely in two layers, and the choledochotomy is closed with absorbable sutures (e.g. PDS) over a T-tube. In approximately 4 weeks, a cholangiogram is performed through the T-tube, and if without pathology, the T-tube can be removed.

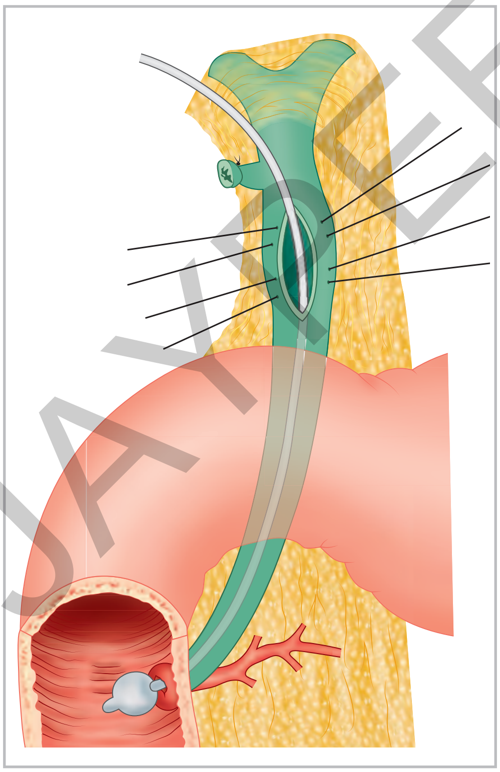

Figure 4.2 After flushing, an attempt to dislodge the CBD stone is made by passing a Fogarty balloon catheter through the choledochotomy into the duodenum. The balloon is inflated and withdrawn until resistance is felt. Care must be taken not to push any stones proximally as the balloon is withdrawn through the choledochotomy. Reprinted from Surgical Clinics 88(6), Verbesy JE, Birkett BH, Common bile duct exploration for choledocholithiasis, pages 1315-1328, 2008, with permission from Elsevier Ltd.

Reconstruction options for open CBD exploration

Options for operative repair or reconstruction after open choledochotomy include: (1) primary repair over a T-tube as described above and (2) bilioenteric diversion. In the setting of a simple choledochotomy with viable edges and a large dilated CBD (i.e. 1 cm), primary repair can be performed in an interrupted fashion with 4-0 or 5-0 absorbable (Vicryl or PDS) suture. Given the potential to narrow the bile duct lumen, many surgeons elect to perform primary closure over a T-tube (12–18 Fr depending on duct diameter) inserted directly through the choledochotomy site. Again, at 4 weeks post-operatively, a cholangiogram is performed through the T-tube and if the biliary system is patent, the tube can be removed (**Figure 4.3**).

If primary closure is not possible given a small diameter duct or the presence of a distal CBD stricture, a bilioenteric anastomosis can be performed. Options for bilioenteric anastomosis include:

- Side-to-side choledochoduodenostomy
- Side-to-side choledochojejunostomy
- End-to-side choledochoduodenostomy
- End-to-side choledochojejunostomy

Although a duodenal anastomosis is an acceptable repair and has the advantage of allowing subsequent endoscopic access, the frequency with which it is performed in clinical practice seems to be limited. Most surgeons reserve the procedure for drainage of the CBD in high-risk patients who otherwise might not withstand a longer operative reconstruction with a Roux limb of jejunum. In the vast majority of cases in which bilioenteric anastomosis is required, a Roux-en-Y choledochojejunostomy is the most commonly performed. In this approach, a 40–60 cm retrocolic Roux limb is brought in proximity to the CBD in preparation for the anastomosis. Side-to-side anastomosis is preferable, as it has been shown to maintain better patency than end-to-side reconstruction. When sufficient CBD length is available to construct a side-to-side anastomosis, the anterior bile duct wall is opened sharply in the longitudinal direction for a distance of 3–4 cm. A 3–4 cm corresponding enterotomy is made in the antimesenteric side of the Roux limb several centimeters from the terminal staple line. Several stay sutures may be placed to approximate the bile duct and jejunum. The anastomosis is then sewn with 4-0 or 5-0 absorbable suture in an interrupted or running fashion, taking care to approximate the bowel mucosa to full thickness CBD, and converting the longitudinal ductomy into a transverse orientation. Specifically, each side of the midpoint of the longitudinal ductotomy is sewn to each end of the jejunal enterotomy, thus creating a 'fish-mouth' type of configuration. In a final step, the Roux limb is anchored to the underside of the liver with several seromuscular interrupted sutures on either side, relieving any tension from the repair (**Figures 4.4** and **4.5**).

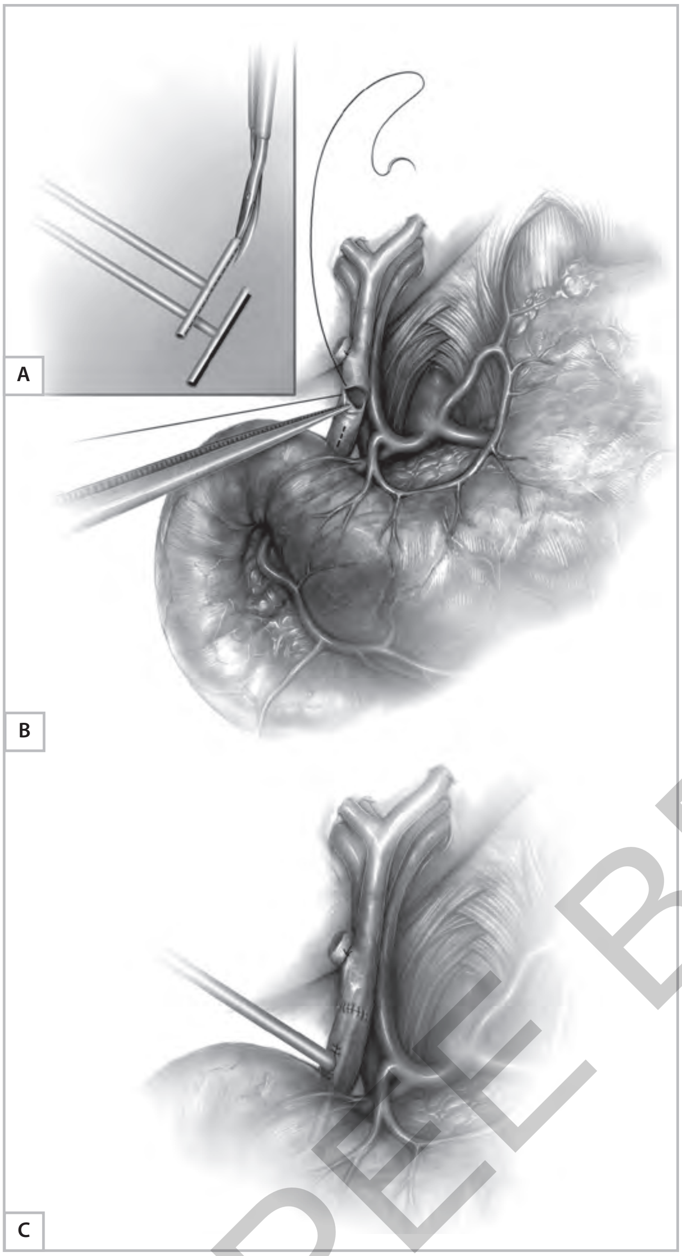

Figure 4.3 Primary repair of the CBD after CBD exploration. (A) The T-tube is modified by removing the back wall, reducing obstruction and allowing for ease of removal when the time is appropriate. (B) The lateral aspects of the incised bile duct are reapproximated with the aid of fine stay sutures. (C) The duct is primarily closed transversely in an interrupted fashion using 4-0 absorbable suture, taking care to approximate mucosa to mucosa. Before closure of the anterior wall is complete, a T-tube is inserted across the anastomosis either through the original choledochotomy or via a separate choledochotomy downstream. The choledochostomy is closed around the T-tube and the T-tube is brought out through a stab incision in the abdominal wall. Reprinted from Operative Techniques in General Surgery 9(4), Haney JC, Pappas TN, Management of common bile duct injuries, pages 175-184, 2007, with permission from Elsevier Ltd.

Along with being more commonly required in the setting of operative reconstruction for CBD injury, an end-to-side bilioenteric anastomosis may be necessary when there is an insufficient length of exposed CBD to perform a side-to-side anastomosis. In this approach, the CBD can be spatulated if it is narrow and anastomosed to the antimesenteric enterotomy using 4-0 or 5-0 absorbable sutures that approximate the bowel mucosa to full thickness CBD. If the CBD is narrow (e.g. <8 mm), an interrupted suture technique is recommended where the posterior row knots can be tied on the inside and the anterior is tied outside the lumen. If the CBD is dilated as a result of distal obstruction, a running technique is acceptable. The major disadvantages of the end-to-side technique, remains a decreased long-term patency rate when compared with the side-to-side approach and loss of endoscopic access to the biliary system when a Roux-en-Y jejunal limb is utilized as opposed to duodenum.

Unfortunately, complications after biliary reconstruction are not uncommon. In the largest single center experience after bilioenteric anastomosis reported from Johns Hopkins, post-operative complications were experienced by 42% of patients. The most common complications included wound infection, biloma, anastomotic leak, biliary stent complications and biliary stricture. In the setting of a post-operative biliary stricture, a cholangiogram should be performed to ascertain the anatomy. If the bile duct is anastomosed to the duodenum, ERCP and stenting is the preferred mode of management. In the setting of jejunal reconstructions, however, all therapeutic interventions are relegated to a PTC or reoperative approach.

Although cholangitis complicating bilioenteric anatomosis is usually in the setting of an anastomotic stricture, a rare but important potential etiology is 'sump syndrome', a siphoning effect causing bile stasis, reflux of enteric contents into the CBD and cholangitis without evidence of anastomotic stricture. The syndrome is characterized by a variety of symptoms such as right upper quadrant or epigastric pain, fevers, chills, acholic stools, malabsorption, pancreatitis and hepatic abscesses. Of note, the pathophysiology of the syndrome seems to differ when one compares side-to-side and end-to-side choledochoduodenostomy or choledoco- and hepaticojejunostomy. In side-to-side choledochoduodenostomy, the segment of the CBD between the anastomosis and the ampulla of Vater serves as a reservoir of stagnant bile serving as the nidus for formation of debris,

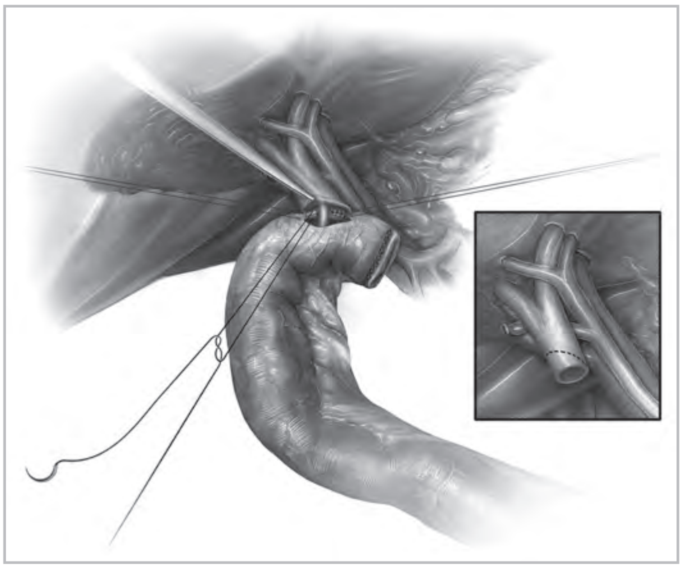

Figure 4.4 Operative reconstruction following CBD exploration: End-to-side choledochojejunostomy. The CBD is spatulated and anastomosed to the antimesenteric enterotomy using interruped 4-0 or 5-0 mucosa-to-mucosa sutures with knots tied on the inside. Reprinted from Operative Techniques in General Surgery 9(4), Haney JC, Pappas TN, Management of common bile duct injuries, pages 175-184, 2007, with permission from Elsevier Ltd.

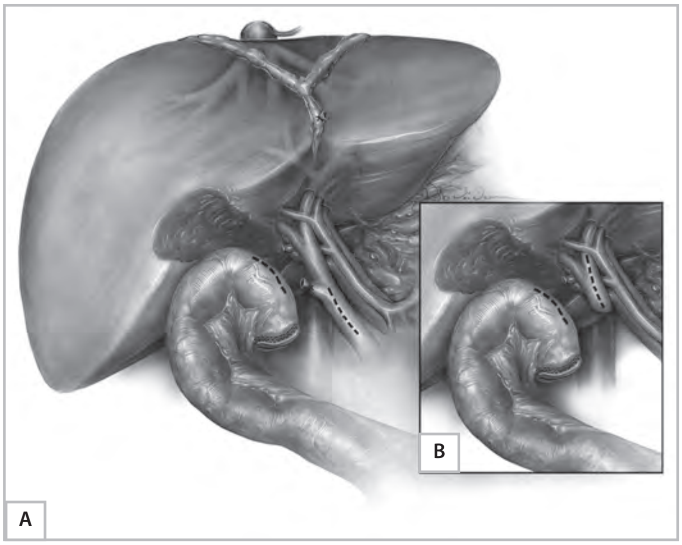

Figure 4.5 Operative reconstruction following CBD exploration: Side-to-side choledochojejunostomy. (A) Depiction of a side-to-side bilioenteric anastomosis when there is sufficient common duct stump. (B) Depiction of a side-to-side bilioenteric anastomosis when extension onto the left or right hepatic duct is required to gain sufficient length. Reprinted from Operative Techniques in General Surgery 9(4), Haney JC, Pappas TN, Management of common bile duct injuries, pages 175-184, 2007, with permission from Elsevier Ltd.

stones, and bactobilia causing cholangitis and/or pancreatitis. In the end-to-side approach, however, enteric material is thought to reflux directly into the biliary tree causing obstruction of ducts and stone formation. Many surgeons elect to not perform reconstructive choledochoduodenostomy because of the potential morbidity of this syndrome. When compared to choledochoduodenostomy, however, choledocho- and hepaticojejunostomy are associated with a markedly lower incidence of this sump phenomenon. When it does occur, the cause of the syndrome is thought to be related to a short Roux limb allowing reflux of food back into the biliary tree.

In the presence of 'sump syndrome' pathology, therapeutic management differs depending on the type of bilioenteric anastomosis performed. In the case of choledoduodenostomy, the initial management is endoscopic removal of obstructing food, stones, or debris. Some studies, however, have suggested a recurrence rate as high as 19% with initial endoscopic management, with the appearance of symptoms occurring between 31 and 72 months after the index procedure. In the case of reconstruction via choledochojejunostomy, endoscopic access for ductal clearance is usually precluded by the enteric anatomy. In these cases, PTC drainage can be used to temporize the patient in the setting of cholangitis, but operative lengthening of the Roux limb may ultimately be required to alter the underlying pathophysiology and prevent recurrence of symptoms.

Laparoscopic CBD exploration

In the current era, more than 80% of gallbladders are removed laparoscopically. It is not surprising then that LCBDE is subsequently being performed with increasing frequency. Although laparoscopic cholecystectomy is a basic laparoscopic technique that is considered within the scope of practice of all graduating general surgery trainees, associated LCBDE in the setting of intraoperative evidence of choledocholithiasis requires an advanced laparoscopic skillset and is often only practiced by a select group of surgeons with additional laparoscopic training. While possessing the inherent advantages previously referenced, LCBDE is still associated with morbidity and mortality quoted between 2–17% and 4–20%, respectively.

There are two different approaches for management of choledocholithiasis via the laparoscopic approach: transcystic common bile duct exploration (TC-CBDE) and laparoscopic choledochotomy (LCBDE-C). The choice of approach is based on several characteristics: (1) stone size and quantity, (2) ductal anatomy, and (3) level of surgeon expertise. If feasible, the transcystic approach is usually preferred, and is reported to be successful in 85– 95% of patients with outcomes similar to those patients undergoing laparoscopic cholecystectomy without concomitant bile duct exploration.

Once a filling defect is identified on cholangiogram, ancillary operating room personnel should have ready access to the additional equipment required to complete the LCBDE. A list of required equipment and supplies is listed in **Table 4.1**.

Transcystic approach

If stones are thought to be small (i.e. <4 mm in diameter), the surgeon should first attempt to mechanically flush the stones from the duct using saline introduced via a cystic duct angiocatheter. Prior to making a partial incision in the cystic duct, clips should be applied proximally on the gallbladder side to prevent bile and stone spillage. To facilitate antegrade egress of stones into the duodenum, 1 mg of glucagon can be administered intravenously to relax the sphincter of Oddi. After waiting 3–4 minutes for sphincter relaxation, the catheter is flushed with saline and cholangiography is repeated (**Figure 4.6a**).

If one is unable to clear the duct via a simple saline flush, a Fogarty balloon embolectomy catheter can be used to attempt removal. In this approach, a 4 Fr Fogarty is inserted directly into the cystic duct and beyond the stones (ideally into the duodenum) as confirmed by fluoroscopy. The balloon is then inflated and slowly drawn back. Retrieved stones are allowed to fall freely into the abdomen, and can then be retrieved by laparoscopic graspers. When applying this technique, care must be taken to not push stones back more proximally into the common hepatic duct as the inflated balloon catheter is pulled through the cystic duct opening.

Another option is to introduce a choledochoscope through the cystic duct in an attempt to clear stones under direct visualization. To begin, the cystic duct is dilated if necessary (**Figure 4.6b**). In many cases this is not necessary as the duct is often already dilated from the passage of stones into the CBD and relative obstruction. If dilatation is required, using a 5-mm scope, a guidewire is passed through the cystic duct and advanced until it is visualized in the CBD by fluoroscopy (**Figure 4.6c**). Balloon angioplasty (5 Fr angioplasty catheter with an 8-mm balloon) or pneumatic dilators are inserted in an over-the-wire fashion until the duct is capable of accepting a 9 or 10 Fr choledochoscope. Most advocate that the duct should not be dilated to greater than 8 mm. Once introduced, great care should be taken not to damage the sensitive fiberoptics of the choledochoscope. It should be noted that the utilization of this technique does require additional equipment such as an additional light source, camera and monitor to allow video splitting in order to view both the laparoscopic and choledochoscopic views simultaneously.

Once a stone is encountered with the scope, a wire retrieval basket is passed via the watertight working port. The stone is grasped under direct visualization and pulled back until it contacts the end of the scope. The basket and scope are then removed as one unit and the stone is released into the abdominal cavity where it can later be retrieved by graspers. To confirm ductal clearance, a completion

Table 4.1 Equipment required for LCBDE.

Laparoscopic	1. Flexible choledochoscope or ureteroscope with 1.2 mm working channel 2. Second video monitor, camera and light source for choledochoscope 3. Pressurized saline connection for working port of choledochoscope 4. Fluoroscope (C-arm) 5. Additional 5 mm port with 3 mm inner cannula 6. Laparoscopic padded graspers for manipulation of choledochoscope
Devices for retrieval	1. 4 Fr Fogarty catheters 2. Segura or Dormia type wire baskets for stone retrieval 3. 0.035-in flexible tipped hydrophilic guidewire (>90 cm)
Optional	1. 14 Fr T-tube 2. 12 Fr abdominal wall introducer sheath 3. 5 Fr angioplasty catheter with 8-mm balloon 4. Glucagon (1–2 mg) for sphincter of Oddi relaxation

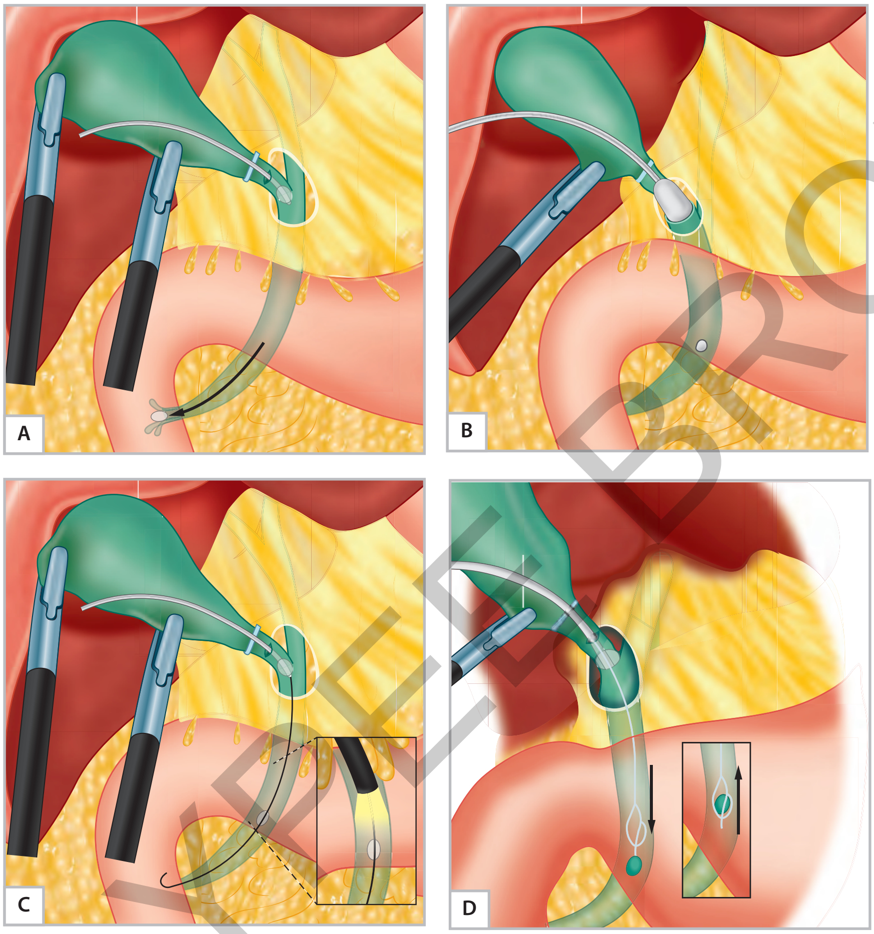

Figure 4.6 Transcystic bile duct exploration. (A) Flush technique. (B) Dilation of the cystic duct. (C) Choledochoscopy. (D) Basket retrieval of common duct stone.

cholangiogram should be performed. The cystic duct division must then be completed after applying two clips distally.

The transcystic approach is limited in the following clinical situations: (1) stones in the hepatic duct or proximal to the cystic-CBD junction, (2) the presence of multiple stones (>9), (3) stones larger than 1 cm in diameter, and (4) the presence of a small cystic duct. In these scenarios, a LCBDE via choledochotomy may be performed. It should be noted that before this approach is utilized, the CBD must be of sufficient diameter (> 6 mm) otherwise the risk of subsequent biliary stricture outweighs the benefit of the single staged procedure. To begin, two stay sutures are laparoscopically placed on the CBD to facilitate eversion of the duct during choledochoscopy. A choledochotomy incision is then made longitudinally with a pair of laparoscopic scissors, taking care to avoid damaging the lateral blood supply at the 3 and 9 o'clock positions. The extent of the excision should be determined by the diameter of the largest stone (often 1 cm), however, care should be taken not to extend the incision more than is required for stone extraction to avoid difficulties with intracorporeal closure. Once the choledochotomy has been made, the procedural approaches to stone retrieval remain the same as those previously outlined in detail for the transcystic approach (i.e. flush, Fogarty balloon catheter, or wire basket via the choledochoscope). At completion of the LCBDE-C, the incision can either be closed primarily or over a T-tube, depending on the duct diameter. If used, a T-tube is placed through the choledochotomy site before the incision is closed via interrupted intracorporeally placed sutures. Indications for closure over a T-tube include the need for decompression of the CBD in the setting of residual stones or ductal edema, the desire to obtain post-operative visualization of the ducts (i.e. T-tube cholangiogram), a relatively narrow CBD (<8 mm), and the need for ductal access to perform post-operative removal of residual stones.

Despite a significant learning curve, LCBDE has been met with impressive success rates reaching as high as 93.3% in a recent Cochrane review. Mortality has been quoted at less than 1%. Minor morbidity is upwards of 10% and has been characterized by nausea, emesis, diarrhea, and urinary retention. Major complications include wound infections, biliary strictures/leaks, subhepatic fluid collections or abscesses, and multi-organ system failure. Although reports of long-term follow-up are not prolific, the actual incidence of these major complications in patients undergoing LCBDE appears to be low. Despite high initial set-up costs and the requirement for advanced laparoscopic technique, LCBDE is a safe, effective, and economically feasible approach to treating choledocholithiasis that carries with it a lower morbidity and mortality when compared to other therapeutic modalities such as ERCP.

CONCLUSION

With an incidence of nearly 20% in the setting of symptomatic cholelithiasis, the management of concomitant choledocholithiasis represents an important therapeutic dialogue within the medical community. Many options exist for the management of this pathology including ERCP (pre-, intra-, or post-operatively), LCBDE, or in select cases, open common duct exploration. With the greater availability of and reduced overall cost of minimally invasive technologies, ERCP and laparoscopic approaches have risen to the forefront of this discussion. The choice of a minimally invasive modality for stone retrieval is dependent upon patient history and characteristics, timing of diagnosis, resource availability, and practitioner skill and comfort level. Although both ERCP and LCBDE exhibit similar stone clearance rates in head-to-head analysis, the lower morbidity, mortality, and overall improved cost-effectiveness of the laparoscopic approach make it an appealing modality in medical arenas in which there is both resource availability and adequately trained staff. When the laparoscopic approach is unsuccessful, post-operative ERCP and open CBD exploration remain the mainstays of therapy.

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