Common bile duct exploration

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INTRODUCTION — Common bile duct (CBD) stones are identified in 10 to 15 percent of patients undergoing surgery for symptomatic cholelithiasis [1]. CBD stones require extraction to avoid complications, such as acute suppurative cholangitis, obstructive jaundice, hepatic abscess, and acute pancreatitis.

Traditionally, CBD stones were diagnosed with intraoperative cholangiography and treated with open CBD exploration. Advances in preoperative imaging technology such as magnetic resonance cholangiopancreatography (MRCP) (image 1 and image 2) and endoscopic ultrasound (image 3), as well as the development of endoscopic retrograde cholangiopancreatography (ERCP), and minimally invasive surgical techniques have allowed for less invasive and more accurate methods of identifying and treating CBD stones.

This topic will review laparoscopic and open CBD exploration. The diagnosis and the endoscopic treatment of choledocholithiasis are discussed elsewhere. (See "Choledocholithiasis: Clinical manifestations, diagnosis, and management" and "Endoscopic management of bile duct stones: Standard techniques and mechanical lithotripsy").

IDENTIFICATION OF CBD STONES — All patients with symptomatic cholelithiasis must be evaluated to avoid the complications of retained stones. Clinical findings suggestive of CBD stones include right upper quadrant pain with radiation to the back, jaundice, cholangitis, and pancreatitis.

Transabdominal right upper quadrant ultrasonography and liver function tests are the initial studies of choice for patients with cholelithiasis. Elevated liver function tests, age >55 years, and CBD dilation are all predictive of CBD stones and mandate further evaluation [2]. These results along with the clinical presentation can be used to stratify the risk of CBD stones prior to performing cholecystectomy. The probability of having CBD stones can then be used to plan appropriate intervention (algorithm 1). The preoperative evaluation of suspected choledocholithiasis is discussed in detail elsewhere. (See "Choledocholithiasis: Clinical manifestations, diagnosis, and management").

INDICATIONS FOR CBD EXPLORATION — Exploration of the CBD should be performed in all patients in whom CBD stones have been identified and who are surgical candidates and have failed, or are not candidates for, endoscopic therapy. Percutaneous transhepatic cholangiography, electrohydraulic lithotripsy, and laser lithotripsy may be useful in a small number of selected patients who are not candidates for surgery or endoscopic therapy. (See "Percutaneous transhepatic cholangiography" and "Electrohydraulic lithotripsy in the treatment of bile and pancreatic duct stones" and "Laser lithotripsy for the treatment of gallstones").

PREOPERATIVE PREPARATION — Informed consent should include a discussion of the risks, benefits, and alternatives of CBD exploration. The patient should be counseled regarding the possibility of bile duct leak, abscess, and retained stones.

Prophylactic antibiotics — Patients with suspected and confirmed CBD stones should be given perioperative antibiotics. A first- or second-generation cephalosporin is recommended within one hour of the incision (table 1) [3]. (See "Antimicrobial prophylaxis for prevention of surgical site infection in adults", section on "Antimicrobial prophylaxis").

Equipment — Appropriate equipment should be readily available including 3 to 5 French (F) biliary Fogarty catheters, wire baskets, 0.0035 inch guidewire, balloon (8 mm outer diameter) and/or mechanical (7 to 12 F) dilators, 3 to 5 mm choledochoscope with 1.1 mm or larger working
channel, loop ligatures, and T-tubes. Additional choledochoscopic equipment includes a separate light source, an adaptor to allow simultaneous irrigation via biopsy channel, second camera, second monitor, or picture-in-picture display with video switcher.

**Fluoroscopy** — Fluoroscopy support should be available for all patients undergoing cholecystectomy, and radiology should be contacted for a C-arm fluoroscope and appropriate support personnel as soon as the necessity for intraoperative cholangiography is identified.

**Deep venous thrombosis prophylaxis** — For patients undergoing general anesthesia, primary prophylaxis for prevention of deep venous thrombosis, such as sequential compression devices, should be employed (table 2). (See "Prevention of venous thromboembolic disease in surgical patients".)

A surgical timeout should be performed with the entire operating room team (anesthesiologist, surgeon, nurse, scrub technician) to assure correct patient identity, intended operation, and the informed consent (table 3). A preoperative checklist is a good way to assure that all safety issues have been addressed.

**INTRAOPERATIVE CHOLANGIOGRAPHY** — When a decision has been made to perform CBD exploration, intraoperative cholangiography may be performed to confirm the diagnosis and outline the biliary anatomy before the CBD exploration is undertaken. Although some surgeons perform routine intraoperative cholangiography before CBD exploration, we selectively perform intraoperative cholangiography based upon findings of elevated liver function tests, a dilated common bile duct (>6 mm), or a history of pancreatitis. Patients who present with jaundice may be best evaluated preoperatively using ERCP [4].

The catheter for intraoperative cholangiography is placed after careful dissection achieves the critical view of safety (figure 1). (See "Laparoscopic cholecystectomy", section on 'Critical view of safety'.)

For laparoscopic intraoperative cholangiography, a clip is applied proximally across the cystic duct once it is well seen. Stay sutures may be placed on either side of the planned bile duct incision. An incomplete vertical ductotomy is created, taking care not to injure the posterior wall of the duct, and the contents of the duct are milked toward the ductotomy. A cholangiogram catheter (4 to 5 F) with a metal reinforced tip is inserted through a transabdominal 14-gauge angiocatheter that has been placed in the right upper quadrant and into the abdomen.

The catheter is manipulated into the cystic duct with laparoscopic instruments. There are cholangiogram catheters available on the market that secure the catheter and occlude the duct after placement either via grasping jaws or an inflatable balloon. Alternatively, a clip or a cholangiogram clamp can be loosely applied around the duct with the catheter. Placement of a hydrophilic guidewire through the cholangiogram catheter facilitates placement of instruments for CBD stone extraction and dilatation of the cystic duct with balloon catheters or mechanical dilators if necessary [5].

The position and seal of the catheter should be first tested with injection of saline. The saline and water-soluble contrast fluid and tubing must be free of bubbles before performing the cholangiogram, since bubbles can create filling defects which can be confused for stones.

Contrast is then injected under continuous fluoroscopic visualization with a 1:1 dilution of water-soluble contrast and water. The images should be evaluated for the length of the cystic duct and the junction with the CBD, the size of the CBD, free flow of contrast into the duodenum, the intra and extrahepatic biliary anatomy, and the presence of filling defects. If the contrast does not flow freely into the duodenum, administration of sublingual nitroglycerin or IV glucagon is sometimes helpful in relaxing the sphincter of Oddi.

Proximal visualization of the bile ducts must also be confirmed, and techniques to facilitate this include administration of intravenous morphine (to contract the sphincter of Oddi), positioning the patient in steep Trendelenburg, and application of pressure to the distal bile duct with a laparoscopic instrument. Misplacement of the catheter in the CBD should be considered when the proximal biliary tree cannot be visualized. Findings on cholangiography that are suggestive of CBD
stones include dilated bile ducts, filling defects, or failure of contrast flow into the duodenum (image 4) [6].

**SURGICAL APPROACHES FOR CBD EXPLORATION** — Laparoscopic CBD exploration, open CBD exploration, and postoperative ERCP with stone removal are all options for the treatment of CBD stones identified by intraoperative cholangiography. In experienced hands, laparoscopic CBD exploration has a success rate of over 90 percent [7]. The choice of procedure should be guided by patient-specific considerations, training and experience of the surgeon, and available endoscopic expertise.

**Laparoscopic transcystic exploration** — Laparoscopic transcystic exploration of the CBD is the preferred initial technique for most patients requiring CBD exploration [8-11].

For patients with stones smaller than 10 mm and a small bile duct, laparoscopic transcystic exploration of the CBD is the fastest, safest, and least invasive initial approach to CBD exploration compared with laparoscopic choledochotomy alone [9,10]. As an example, in an observational series of 113 patients undergoing CBD exploration, operative time (97 versus 75 minutes), and length of hospital stay (6 versus 2 days) were significantly longer for choledochotomy than for transcystic exploration, although stone clearance and morbidity were similar [11].

Choledochotomy should be reserved for patients with large occluding stones or those in whom the duct cannot be cleared using a transcystic approach. (See 'Laparoscopic choledochotomy' below.)

Conditions for successful and safe transcystic laparoscopic CBD exploration include [12):

- CBD diameter <6 mm
- Stone location distal to the cystic duct/CBD junction
- Cystic duct diameter >4 mm
- Fewer than 6 to 8 stones within the CBD
- Stones smaller than 10 mm

For laparoscopic transcystic exploration, the gallbladder is left in situ and the dome of the gallbladder is grasped and retracted cephalad to facilitate visualization and manipulation (figure 2). After intraoperative cholangiography is performed, potential maneuvers and the general sequence that they should be attempted include [13] :

- **Flushing of the CBD** — Flushing of the distal CBD with warm saline should be the initial maneuver performed for clearance of CBD stones and can be facilitated by intravenous administration of glucagon or dilatation of the cystic duct with a 4 to 6 mm balloon. A laparoscopic grasper can be left secured to the dome of the gallbladder in order to facilitate retraction and visualization throughout the procedure. Flushing of the proximal duct is avoided because small stones could be pushed into hepatic ducts, and may not be retrievable.

- **Biliary balloon catheter extraction** — Biliary balloon catheter extraction is useful for cases with a dilated cystic duct [14]. A 3- to 5-F biliary Fogarty catheter is advanced transcystically under fluoroscopic control distally into the duodenum. Duodenal placement can be confirmed by fluoroscopy or by resistance upon withdrawal of the catheter, indicating that the balloon is adjacent to the ampulla of Vater. The balloon should be deflated and withdrawn slightly. The balloon can then be gently inflated and withdrawn carefully until stones and debris exit from the cystic ductotomy for retrieval with forceps. There is a risk of stone displacement into the common hepatic duct with this procedure since the stones are not grasped directly.

Once the duct has been cleared with flushing and balloon catheters, either transcystic choledochoscopy or fluoroscopically-guided wire basket retrieval can be employed to retrieve any remaining stones. The choice between approaches depends on available expertise and equipment as both have been used successfully.

- **Transcystic choledochoscopy** — Transcystic choledochoscopy may require dilatation of the cystic duct to accommodate the scope, although the cystic duct is usually enlarged due to the passage of stones. The choledochoscope is placed through a 5 mm port and manipulated into
the cystic duct with atraumatic instruments. The choledochoscope can then be advanced through the CBD and into the duodenum. The choledochoscope should be connected to high-pressure saline for irrigation of the duct and to improve visualization. Adaptors for insertion of wire retrieval baskets are necessary. Additional video monitors, or screen-in-screen technology, are utilized for monitoring.

If a stone is seen through the choledochoscope, wire basket retrieval can be performed through the working channel of the scope and offers the advantage of direct visualization of stone capture and withdrawal as compared with fluoroscopically-guided wire basket retrieval. Distal CBD stones can be pushed into the duodenum with the choledochoscope. Proximal stones may require treatment with other techniques since choledochoscopic visualization of the proximal biliary tree is technically challenging.

In an observational series of 113 patients undergoing CBD exploration, operative time (107 versus 75 minutes) was significantly longer for fluoroscopically guided stone retrieval than with choledochoscopy, although stone clearance and morbidity were similar [11].

**Fluoroscopically-guided wire basket retrieval** — Fluoroscopically-guided wire basket retrieval of stones can be performed if fluoroscopy and specialized equipment are available [14]. The use of spiral wire baskets with flexible leaders will help avoid CBD injury. The basket is placed through the wire for guidance and advanced under fluoroscopic guidance into the lower common duct or duodenum, then opened and pulled back until the stone is captured. Rates of successful stone retrieval with this technique are reported as 95 percent in several case series [15,16].

Following laparoscopic transcystic exploration, cholangiographic confirmation of duct clearance should be performed with intraoperative cholangiography (image 5). The cholecystectomy is completed and the cystic duct stump is secured with a clip or a loop ligature. Loop ligatures minimize the possibility of postoperative bile leak for patients with cystic duct dilatation, trauma, or inflammation. Placement of a closed suction drain in the hepatic fossa may be considered to identify and control any bile leakage. (See "Laparoscopic cholecystectomy", section on 'Procedure'.)

**Laparoscopic choledochotomy** — Laparoscopic choledochotomy (LCD) is more technically challenging than laparoscopic transcystic exploration. LCD may be attempted following failed laparoscopic transcystic exploration or for patients who are not candidates for the transcystic approach. Laparoscopic CBD exploration is preferable to postoperative ERCP for stone removal [7,17-20]. A metaanalysis of surgical versus endoscopic treatment of CBD stones including 1351 patients in 13 randomized trials showed that laparoscopic CBD stone clearance was more successful as well as more efficient than pre- and postoperative ERCP with no significant difference in morbidity and mortality [7].

LCD is indicated for patients with [13]:

- Failed laparoscopic transcystic exploration or preoperative endoscopic stone extraction
- Narrow/tortuous cystic duct
- Dilated CBD (6 to 10 mm)
- Large stones (>10 mm)
- Multiple stones
- Stone location proximal to the cystic duct/CBD junction

As is the case for laparoscopic transcystic exploration, the gallbladder is left in situ and the dome of the gallbladder can be grasped and retracted cephalad to facilitate visualization and manipulation. A 30 degree laparoscope should be used to assist with visualization of the supraduodenal CBD.

The cystic duct should be dissected down to the level of the CBD and the tissue overlying the anterior CBD should be cleared. Care should be taken to avoid excessive dissection because this may endanger the blood supply to the duct and thus impair healing. An approximately 1 cm longitudinal ductotomy is created with laparoscopic scissors; stay sutures will help to facilitate manipulation and maintain a seal when saline infusion is used for choledochoscopy. Various techniques such as saline infusion, fluoroscopically-guided balloon or wire basket retrieval, and choledochoscopy should be utilized for extraction of CBD stones and to ensure that the CBD is no longer obstructed, as described above. (See 'Laparoscopic transcystic exploration' above.)
Primary closure of the choledochotomy with interrupted fine monofilament absorbable suture is safer than closure around a T-tube and results in decreased operating time, decreased postoperative and biliary complications, shorter time until return to work, and decreased hospital costs \(^{21-27}\). Absorbable sutures should be used in the bile duct since permanent suture is lithogenic \(^{1}\). Residual stones may be extracted with the use of ERCP.

In cases where there is concern that additional manipulation may be necessary and ERCP expertise is not available, a T-tube \((12\text{-} to\ 16\text{-}F)\) can be placed through the ductotomy (figure 3) and secured in place using fine monofilament absorbable sutures. T-tube drainage has traditionally provided a method for post-operative biliary decompression and postoperative access to the bile duct for cholangiography and possible stone extraction. However, T-tubes can be complicated by bile leak, infection, tube dislodgement, or bile duct obstruction \(^{8}\). In addition, the T-tube can act as a foreign body around which bile pigments and bile salts may precipitate, potentially leading to stone recurrence. If a T-tube is placed, cholangiography should always be performed prior to closure in order to confirm duct clearance and to rule out bile leaks.

Some surgeons place transcystic biliary drainage catheters as an alternative to T-tubes \(^{28}\). These catheters are easier to place than T-tubes and allow for biliary access in the case of retained stones. However, in a study of 63 patients, transcystic biliary drainage catheters resulted in a significantly higher rate of bile leakage as compared to T-tubes (14 versus 3.5 percent respectively).

**Open CBD exploration** — Open CBD exploration remains an important technique and should be part of every gastrointestinal surgeon's armamentarium for treating hepatobiliary diseases. Surgeons performing laparoscopic cholecystectomy should be prepared to convert to open CBD exploration if necessary.

Open CBD exploration should be performed in the following situations:

- Patients with CBD stones who are undergoing open cholecystectomy
- Patients who have failed or suffered complications from laparoscopic CBD exploration
- Patients with severe inflammation in the triangle of Calot
- When laparoscopic equipment, experience, and/or resources are limited

The abdomen is most commonly opened through a right upper quadrant subcostal incision; although a midline approach is acceptable as well. The liver should be retracted superiorly, the duodenum retracted inferiorly, and the stomach retracted to the left. A generous Kocher maneuver should be performed, which will allow for manual palpation and manipulation of the distal common bile duct.

The proximal cystic duct should be ligated to prevent gallstones from migrating from the gallbladder into the cystic duct and CBD. Dissection is carried out on the anterolateral CBD, stay sutures (fine monofilament, absorbable suture) are placed just above the level of the duodenum and the duct is opened longitudinally. The choledochotomy can then be extended with Potts scissors to a length of approximately 1.5 cm.

Stones can initially be extracted using manual manipulation of the CBD. If this is not possible, balloon extraction can be performed with biliary Fogarty catheters, clearing the proximal duct before the distal duct. These catheters are preferred because they are less traumatic than metal forceps \(^{29}\). Saline irrigation can facilitate the removal of fragmented debris by flushing. Choledochoscopy with wire basket retrieval can be employed in the unlikely event that balloon extraction is unsuccessful.

As is the case for LCD exploration, primary closure of the choledochotomy is a safe alternative to T-tube placement (figure 3) in patients undergoing open CBD exploration \(^{21,23,30,31}\).

**PERSISTENT STONES** — Laparoscopic CBD exploration results in stone clearance in over 90 percent of patients \(^{6,32,33}\). Options for management of persistent CBD stones after laparoscopic transcystic exploration include conversion to laparoscopic or open choledochotomy and CBD exploration, postoperative ERCP and stone extraction, percutaneous stone removal, or observation
The choice of procedure should be guided by patient-specific considerations (discussed above), training and experience of the surgeon, and available endoscopic expertise.

Rarely, severely impacted stones are encountered (image 8). Impacted stones are difficult to remove with laparoscopic techniques and remain one of the indications for open CBD exploration. Surgeons who have experience with lithotripsy or duodenotomy with sphincterotomy may be able to complete stone extraction with one of these techniques [34]. However, if experience in sphincterotomy or lithotripsy is not available, the surgeon should place a T-tube and terminate the procedure [35]. The patient should be referred postoperatively to a specialized center where endoscopic or percutaneous removal is usually successful with the use of electrohydraulic or laser lithotripsy in conjunction with sphincterotomy. (See "Laser lithotripsy for the treatment of gallstones" and "Endoscopic management of bile duct stones: Standard techniques and mechanical lithotripsy" and "Electrohydraulic lithotripsy in the treatment of bile and pancreatic duct stones".)

**POSTOPERATIVE MANAGEMENT** — Postoperative care is routine. If closed suction drains were placed at the time of surgery, they are removed within 24 to 48 hours as long as the output is not bilious. Liver function tests (LFTs) should be measured if patients develop complications or if there is a concern for retained stones, but LFTs may take over a week to normalize after surgery [36]. (See "Enzymatic measures of cholestasis (eg, alkaline phosphatase, 5'-nucleotidase, gamma-glutamyl transpeptidase)".)

If a T-tube has been placed, it is clamped when the patient is discharged and flushed with 10 mL of sterile normal saline one to two times a day. A T-tube cholangiogram and measurement of LFTs should be performed prior to T-tube removal in order to confirm duct clearance and integrity. The T-tube may be safely removed in the office setting after a tract has had time to develop; this generally requires four weeks.

**COMPLICATIONS** — Complications of open and laparoscopic CBD exploration include bile duct leak (2 to 6 percent), subhepatic abscess (0.7 percent) and retained stones (3 to 6 percent) [33,37,38]. Compared with patients who had open surgery, patients who had laparoscopic CBD exploration had significantly lower mortality (0.25 versus 5.5 percent), surgical site infection (1.2 versus 10 percent) and overall morbidity (3.7 versus 22 percent) in the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) database [39]. The increased morbidity and mortality in patients who underwent open surgery is likely a reflection of underlying comorbidities or more complicated disease requiring an open approach [40].

Patients who present with persistent fever and leukocytosis, persistent pain, bile leakage around the T-tube or drain, jaundice or rigors after CBD exploration should be evaluated for fluid collections or CBD blockage with ultrasound and a computed tomography (CT) scan. The clinical and radiologic evaluation of a bile leak or obstruction is discussed in detail elsewhere. (See "Complications of laparoscopic cholecystectomy", section on 'Radiologic workup'.)

**SUMMARY AND RECOMMENDATIONS**

- Common bile duct (CBD) stones are identified in 10 to 15 percent of patients undergoing surgery for symptomatic cholelithiasis. Complications of CBD stones include acute suppurative cholangitis, obstructive jaundice, hepatic abscess, and acute pancreatitis. (See 'Introduction' above.)
- Patients with symptomatic cholelithiasis should be evaluated for possible CBD stones. Clinical findings suggestive of CBD stones include right upper quadrant pain with radiation to the back, jaundice, cholangitis, and pancreatitis. The preoperative evaluation includes liver function tests and imaging (typically ultrasonography). Although some surgeons perform routine intraoperative cholangiography prior to CBD exploration, we selectively perform intraoperative cholangiography based upon findings of elevated liver function tests, a dilated common bile duct (>6 mm), or a history of pancreatitis. Patients who present with jaundice may be best evaluated preoperatively using ERCP. (See 'Intraoperative cholangiography' above.)
- Exploration of the CBD should be performed in all patients with CBD stones who have either failed, or are not candidates for, endoscopic therapy and who do not have medical conditions that prohibit surgical intervention. (See 'Indications for CBD exploration' above.)
Laparoscopic CBD exploration, open CBD exploration, and postoperative ERCP with stone removal are all options for the treatment of CBD stones identified by intraoperative cholangiography. Laparoscopic CBD exploration may be performed by a transcystic approach or by choledochotomy. The choice of procedure should be guided by patient-specific considerations, training and experience of the surgeon, and available endoscopic expertise. (See 'Surgical approaches for CBD exploration' above.)

For patients undergoing laparoscopic surgery, we recommend laparoscopic transcystic exploration of the CBD as the initial surgical approach for patients with stones smaller than 10 mm and a small bile duct (Grade 1C). Choledochotomy should be reserved for patients in whom the duct cannot be cleared using a transcystic approach. (See 'Laparoscopic transcystic exploration' above.)

Surgeons performing laparoscopic cholecystectomy should be prepared to convert to open CBD exploration if necessary. (See 'Open CBD exploration' above.)

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REFERENCES


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