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Surg Clin N Am 88 (2008) 1315–1328

SURGICAL
CLINICS OF
NORTH AMERICA

Common Bile Duct Exploration for Choledocholithiasis

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Common bile duct stones represent a significant danger to patients, because they can lead to biliary colic, obstructive jaundice, cholangitis, or pancreatitis. Common bile duct stones either migrate from the gallbladder or form primarily within the bile ducts themselves. Primary stones are more common in South Asia and are usually sequelae of biliary infection and stasis. In the United States and other Western countries, common bile duct stones are predominantly secondary stones, having formed in the gallbladder. In patients who have gallstones, and in whom a cholecystectomy is considered, common bile duct stones can be found preoperatively, intraoperatively, or postoperatively. Ten percent to 15% of patients undergoing a cholecystectomy will be found to have choledocholithiasis at some point during their treatment [1–6]. Of these patients, it is estimated that approximately one third may pass the obstructing common duct stone within 2 months with no intervention [7]. The remainder will require an endoscopic or surgical intervention to relieve the obstruction. Because, at this time, it is impossible to predict into which group a patient will fall, it generally is accepted that in all situations where common bile duct stones are either suspected or confirmed, extraction should be performed.

Preoperative diagnosis and treatment

Choledocholithiasis is suspected preoperatively in those patients who have elevated liver function studies, jaundice, pancreatitis, radiologic signs

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doi:10.1016/j.suc.2008.08.002 *surgical.theclinics.com*

of dilated intra- or extrahepatic ducts, or evidence of common bile duct stones by ultrasound. The most direct method of dealing with choledocholithiasis preoperatively is by endoscopic retrograde cholangiopancreatography (ERCP). ERCP first was reported in 1974 and has gained widespread usage. Decompression of the ductal system can be achieved by means of endoscopic removal of stones with or without sphincterotomy. This procedure has a reported success rate of 70% to 90% [8]. A normal examination, however, will be encountered in 40% to 60% of cases where common bile duct stones are suspected. Therefore, sphincterotomy should be reserved for those patients in whom there is good evidence that a stone is present in the common bile duct. Certainly, ERCP has its share of complications that need to be considered in the decision-making process. Published rates for morbidity from ERCP are approximately 5% to 19%, and mortality has been reported at 0% to 2.3% [8]. The use of magnetic resonance cholangiopancreatography (MRCP) to help select the patients who would benefit most from ERCP is discussed later in this article.

ERCP is an excellent therapeutic option in those centers where the equipment and experienced, qualified endoscopists are readily available, but it does add an extra procedure for the patient, which reduces the effectiveness and efficiency of a laparoscopic approach. Because the published morbidity rates for ERCP and laparoscopic common bile duct exploration are roughly equivalent, ERCP plus or minus sphincterotomy is a good starting point in patients in whom stones are known to be present or strongly suspected, and a laparoscopic cholecystectomy is planned. A recently published Cochrane meta-analysis concluded that, in past years, when open cholecystectomies were common, open common bile duct exploration was superior to ERCP. In the laparoscopic era, however, laparoscopic exploration and ERCP have very similar success and morbidity rates associated with common bile duct clearance [9].

Intraoperative diagnosis and treatment

If the patient has a history of elevated liver function tests or biliary pancreatitis preoperatively, it is important to perform an intraoperative cholangiogram to rule out persistent common bile duct stones. If stones are found during the course of a laparoscopic cholecystectomy, there are three ways of proceeding: laparoscopic common bile duct exploration (LCBDE), conversion to an open common bile exploration (CBDE), or completion of the cholecystectomy with postoperative ERCP. The inherent risk of the last option is that if ERCP is unsuccessful at retrieving the impacted stone, the patient will need to return to the operating room for yet another procedure. If the patient is undergoing an open cholecystectomy, then it is most logical to continue with an open common bile duct exploration.

Postoperative diagnosis and treatment

Occasionally, the patient will have no signs of common bile duct obstruction and a normal cholangiogram intraoperatively (or one is not performed), yet develop signs of choledocholithiasis postoperatively. Most frequently this is because of a stone being pushed down from either the gallbladder or cystic duct into the common bile duct in the course of performing a laparoscopic cholecystectomy. Because the surgery is already complete, the most sensible option for the patient is to undergo ERCP plus or minus sphincterotomy to deal with the problem.

Preoperative imaging

Radiologic assessment of the bile ducts has improved in the past decade. Transabdominal ultrasound often is used as a screening test for common bile duct stones; however, it is not extremely sensitive (sensitivity 0.3, specificity 1.00) [10–12]. In combination with clinical symptoms and laboratory abnormalities, ultrasound examination can help select the patients who need further imaging. With high specificity, if an ultrasound is negative and liver function tests are normal, there is a very small likelihood of common duct stones [12]. CT scans are commonplace, particularly in the emergency room workup of patients, and have been quoted as having sensitivity between 65% and 93%, and a specificity of 84% to 100% (Fig. 1) [13–15]. Better options include MRCP, with a sensitivity and specificity of greater than 90% [13,16–18] (Fig. 2), or endoscopic ultrasound (EUS), also with a sensitivity and specificity of greater than 90% (Fig. 3). All of these studies are purely diagnostic, whereas ERCP has the advantage of being both diagnostic and possibly therapeutic at the same time. Given the complication risk of ERCP, however, these other preoperative screening tools can be very helpful to select out those patients who would benefit most from ERCP.

Indications for common bile duct exploration

Common bile duct exploration is done based on the results of an intraoperative cholangiogram (IOC) or sonogram. Some surgeons advocate for IOC in every patient, because they would argue that, in addition to demonstrating the presence of common bile duct stones, it provides a map of the anatomy and decreases the incidence of bile duct misadventures. On the other hand, many feel that with a good preoperative history, appropriate laboratory tests, and preoperative imaging, extra biliary manipulation is unnecessary. For this group, indications for intraoperative cholangiogram include the history or presence of any of the following:

History of elevated liver function tests
History or presence of jaundice

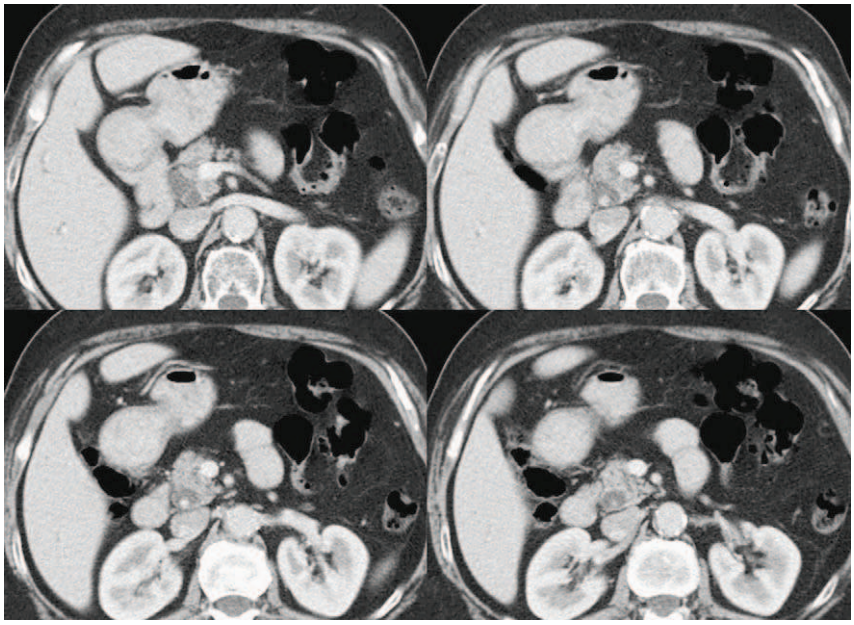


Fig. 1. CT scan demonstrating dilated cystic and common bile duct. Gallstone is seen in common bile duct.

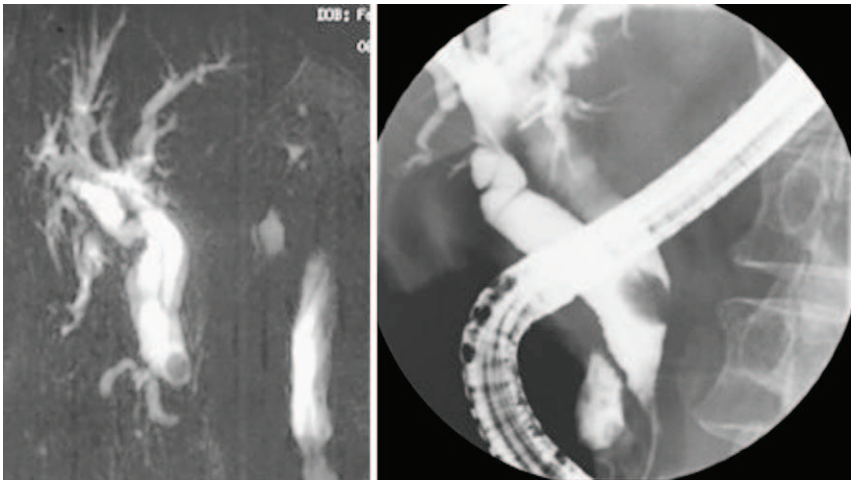


Fig. 2. Magnetic resonance cholangiopancreatography image documenting presence of stone in distal common bile duct. An endoscopic retrograde cholangiopancreatography later verified that finding, and the patient underwent a successful sphincterotomy.

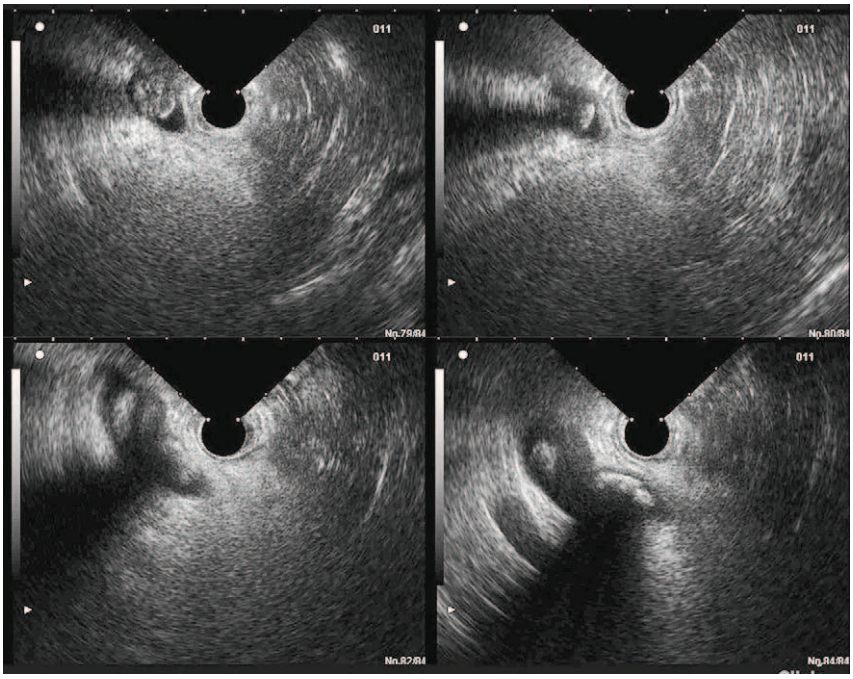


Fig. 3. Endoscopic ultrasound demonstrating common bile duct stone. Ultrasound probe is located in the duodenum, and multiple stones can be seen in the duct, causing shadowing distally.

Biliary pancreatitis
Radiographic evidence of a dilated ductal system
Radiographic visualization of common bile duct stones

Contraindications for laparoscopic or open exploration include an inexperienced surgical team not comfortable with the procedure or lack of necessary equipment.

Open common bile duct exploration

The first open common bile duct exploration was described in 1889 by New York surgeon Robert Abbé. He opened the duct of a 36-year-old woman with severe jaundice, removed a stone, sewed the duct closed with fine silk, and returned her to perfect health. Other sources give credit for the first exploration to Londoner J.K. Thornton, Swiss surgeon Ludwig Courvoisier, or Herman Kümmell of Hamburg, Germany [19].

Although very rare today given the success of stone removal by means of endoscopic or laparoscopic techniques, there are still several indications for proceeding with an open bile duct exploration. The most obvious example is those patients who are undergoing another open abdominal procedure or an

open cholecystectomy because of concomitant problems or past surgeries, making a laparoscopic approach very difficult. In addition, some patients will undergo an open exploration because of conversion of a laparoscopic procedure to an open one. A relative indication for open exploration is large or multiple stones or the need to perform a transduodenal sphincteroplasty. Finally, open common bile duct exploration still is considered the gold standard for the removal of common bile duct stones. If the surgical team does not have the experience or feels uncomfortable with the laparoscopic approach, or qualified endoscopists are not available, an open technique should be employed.

The common bile duct is exposed in the free border of the lesser omentum, above the duodenum. If this is difficult because of dense adhesions or inflammation, a small needle can be used to aspirate bile from the structure thought to be the bile duct to confirm the anatomy. In addition, a transcystic intraoperative cholangiogram can be very helpful in verifying the anatomy. Two stay sutures using 4-0 chromic stitches are placed on either side of the planned bile duct incision. An anterior, vertical choledochotomy is made. Great care should be taken to not injure the posterior wall of the duct when making the initial incision. Some surgeons alternatively will place the stay sutures after making the incision.

The first tactic to remove the stones is flushing of the duct. A small red rubber catheter attached to a saline syringe is placed distally into the duct. The distal duct is irrigated, and small stones often will float back toward the choledochotomy and out. If the saline injection is not returning out the incision, the catheter is too far in and past the sphincter. At this point, some surgeons will flush the proximal duct, but more frequently this is avoided because of the fear of pushing small stones further up into small hepatic radicals, where they can become very difficult to dislodge.

A Fogarty balloon catheter, with the balloon deflated, is passed distally through the choledochotomy and advanced distally into the duodenum. The balloon is inflated, and the catheter is withdrawn until resistance is felt at the sphincter of Oddi (Fig. 4). At that point, the balloon is deflated, tension on the catheter released, and the catheter withdrawn a small amount and then reinflated; this is repeated until the catheter is just above the sphincter. The catheter is then gently completely withdrawn, hopefully bringing out any remaining stones with it through the choledochotomy (Fig. 5). The catheter then is passed proximally to retrieve any proximal stones also (Fig. 6) [20].

After attempting to clear the duct with irrigation and balloon catheters, direct vision using a flexible fiber choledochoscope needs to be performed. If a stone is seen using the choledochoscope, then a retrieval basket is passed through the instrument channel of the choledochoscope, passed beyond the stone, opened, and gently and slowly pulled back to ensnare the stone. Once caught in the basket, it is closed under direct vision, and the choledochoscope and basket are removed from the common bile duct. The older rigid

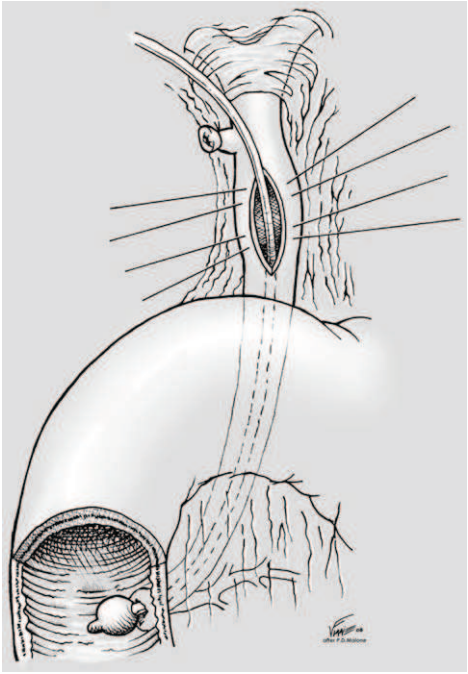


Fig. 4. After flushing, an initial attempt to dislodge a stone is done by passing a Fogarty balloon catheter though the choledochotomy into the duodenum. The balloon then is inflated and withdrawn until resistance is felt at the Sphincter of Oddi.

instruments, such as Randall stone forceps or scoops, have no place today, as they can cause injury to the bile duct and sphincter.

There may be instances where an impacted stone remains despite all of these described methods of dislodgement. In these difficult cases, intracorporeal electrohydraulic or laser lithotripsy can be attempted under direct vision, washing the fragments through into the duodenum. This is often not available, however; if it is, it must be done very cautiously, as it is easy to cause ductal injury.

If all of the previously mentioned maneuvers fail, the final step is to perform a transduodenal sphincterotomy. The duodenum is kocherized (dissected medially) and the area palpated to localize the stone. If the stone cannot be felt, a Fogarty catheter or probe can be placed through the choledochotomy and passed down toward the duodenum as a landmark for the sphincter. A 2 to 4 cm duodenotomy incision is made on the anterior wall of the second portion of the duodenum opposite the stone or probe. Internally, the ampulla should be visualized. Two traction sutures are placed in the duodenal mucosa at both ends of the incision so the duodenal wall can be everted and better exposure to the ampulla obtained. A sphincterotomy

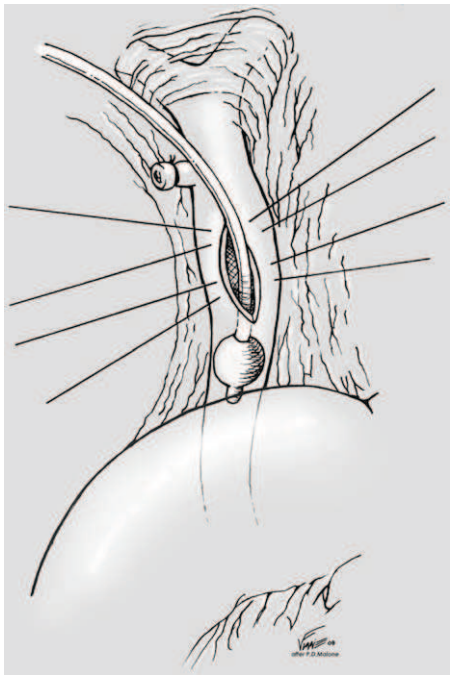


Fig. 5. When resistance is felt at the Sphincter of Oddi, the balloon is deflated, withdrawn a small amount and then reinflated. The balloon at this point should be positioned just above the sphincter. The Fogarty catheter then is withdrawn completely, bringing with it any stones it catches through the choledochotomy.

is performed at the 10 o'clock position, which should be directly opposite the most common position for the pancreatic duct [20]. The incision is made down onto the stone or probe. After the stone is extracted successfully, the sphincterotomy incision is matured with vicryl sutures to approximate the common bile duct mucosa with the duodenal mucosa. A catheter should be passed through the sphincter at the conclusion of this maneuver to verify its patency. The duodenotomy then is closed in two layers with vicryl and silk. Finally, a T-tube is place through the choledochotomy site, and the incision is closed with interrupted 4-0 vicryl sutures. Absorbable sutures always should be used in the bile duct, because the suture material can be lithogenic. The benefits of T-tube placement are maintaining ductal patency in the setting of edema and providing easy access for postoperative imaging.

In 2 to 3 weeks, a repeat cholangiogram is obtained through the T-tube. If this study is normal, the T-tube can be removed. An alternative treatment plan for a patient who has an impacted stone is to place a T-tube to drain the duct, and 4 weeks later, when the edema associated with the impaction has settled, the stones are extracted through the T-tube tract.

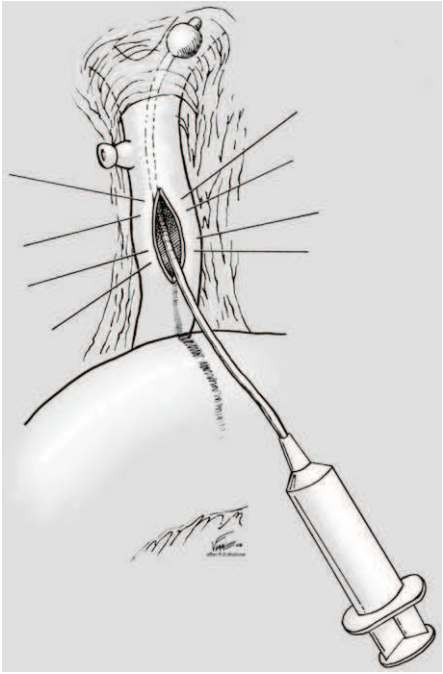


Fig. 6. After clearing the distal duct, the Fogarty catheter can be passed proximally to retrieve any proximal stones. Prior to this, some surgeons will flush the proximal ducts, but this frequently is avoided so that smaller stones will not be pushed up into small hepatic radicals. The catheter is withdrawn, hopefully pulling down any proximal stones out through the choledochotomy.

Laparoscopic common bile duct exploration

Because over 80% of gallbladders are removed laparoscopically, laparoscopic common bile duct exploration is being performed with increasing frequency. It is a difficult procedure, however, that requires a great deal of laparoscopic skill. Therefore it only is done by a select group of laparoscopic surgeons. The advantages are clear; the gallbladder and stones are taken care of simultaneously in a minimally invasive manner that leads to shorter hospital stays and less pain than the corresponding open procedure or laparoscopic cholecystectomy/ERCP combination. Still, laparoscopic common bile duct exploration has its own share of complications, and morbidity rates are quoted between 2% to 17%. Reported mortality rates are 1% to 5% [9]. Compared with the 4% to 20% mortality rates long quoted for open elective and emergency procedures in patients over 70 years old [21–24], there may be a great advantage if laparoscopic techniques are successful.

Laparoscopic common bile duct exploration can be achieved by means of two methods: transcystic or choledochotomy. If technically feasible, the

transcystic approach is the preferred method, because it is the least invasive option, the quickest, and the least expensive. This approach, however, only will be successful for smaller stones and a duct that can be dilated to accept a 9 or 10 Fr diameter choledochoscope. Other factors that will dictate which approach is used include the presence and location of multiple stones, the anatomy of the cystic duct in relation to the common bile duct, the degree of inflammation in the surrounding areas, and the ability of the surgeon to complete a complex laparoscopic procedure that includes intracorporeal suturing of a small structure [8].

It is most important to first gather all of the equipment that may be needed during the procedure. The critical items include the following:

Second video camera
Cholangiogram catheter
Pneumatic dilators
4 or 5 Fr Fogarty balloon catheter
Stone extractor basket
T-tube
Flexible choledochoscope
Glucagon 1 mg

Most surgeons will use fluoroscopic imaging as their method of intraoperative imaging; however, percutaneous cholangiography and intraoperative ultrasonography also can be used. If fluoroscopic guidance will be used, it is also necessary to ensure a C-arm fluoroscope is in the operating room and a person capable of operating it is available.

The procedure starts with dilatation of the cystic duct if necessary. The cystic duct frequently already is dilated from the passage of stones into the common bile duct or small bowel. If not, a guidewire is placed through the cystic duct and advanced until it is in the common duct. Pneumatic dilators are inserted over the wire until the cystic duct is capable of accepting a 9 or 10 Fr choledochoscope, but not greater than 8 mm [25]. A 3 mm scope can be used for the procedure, but a 5 mm one is preferable because of better illumination and the access for larger instruments it provides.

If the transcystic approach is not going to provide adequate access, a choledochotomy is performed, provided that the common bile duct is dilated. This method of access is indicated for patients who have larger or multiple stones, proximally located stones, anatomy not conducive to the transcystic approach, or after a failed attempt transcystically. Two stay sutures on the common bile duct are optional [25]. An incision is made longitudinally, avoiding the common bile duct blood supply at the 3 and 9 o'clock positions. This can be performed using a laparoscopic scissors. The incision needs to be at least as long as the largest stone (usually approximately 1 cm). Care should be taken not to make the incision too large, as this will result in a longer and more difficult closure with intracorporeal suturing.

Whether through the cystic duct or the common bile duct, the remainder of the procedure is performed in a similar fashion. The first technique used to try to remove any stones is to irrigate the common bile duct using normal saline. This only will be successful for very small stones (<3 mm) or sludge. As an adjunct measure, the surgeon can ask the anesthesiologist to give the patient 1 mg of intravenous glucagon to relax the sphincter of Oddi and increase the chances of success [8]. Success or failure should be documented by choledochoscopy.

If the stones remain after flushing, the surgeon should proceed to trying to dislodge them using balloon Fogarty catheters. The balloon catheter is placed through the sleeve in the abdominal wall and inserted into the common duct, either by means of the cystic duct or through the choledochotomy. An endoscopic forceps can be used in the other hand to facilitate this step. The balloon catheter is advanced as far as possible, ideally into the duodenum. The balloon then is inflated and slowly withdrawn until resistance is felt. This should represent the balloon meeting the sphincter. At this point, the tension on the catheter should be released, the balloon deflated, the catheter withdrawn slightly, and the balloon reinflated to see if it is above the sphincter. This maneuver is repeated until the balloon is just above the sphincter and below a stone. With slow, deliberate withdrawal of the balloon catheter, small stones may be extracted through the cystic duct or choledochostomy.

If larger stones still remain despite these procedures, several other techniques may be employed. First, a choledochoscope may be used in combination with the balloon catheters, because direct visualization may increase the chance of success. Second, baskets can be used to try to capture the stones directly. The basket is inserted through the instrument channel or operating port of the choledochoscope into the common bile duct. The basket is advanced past the stone under direct vision, opened, and withdrawn to ensnare the stone. The basket is closed carefully to entrap the stone, and then the choledochoscope, basket, and stone are removed from the common bile duct. Confirmation of a clear duct should be made with choledochoscopic visualization.

If the stone is large or impacted, all of these maneuvers may fail, and lithotripsy can be tried or a T-tube placed and the stone removed postoperatively. Frequently, the choledochoscope will have limited usage through the cystic duct, because the anatomy will not allow the scope to turn and advance into the proximal duct. If this poses a problem, the incision in the cystic duct can be lengthened down to the junction of the cystic and common bile ducts. If the stone is visualized, a combination of flushing, balloon catheter use, and basket retrieval under direct visualization may be successful. There have been various attempts at the usage of lithotripsy at this juncture to destroy the stones and flush the fragments from the duct. This is difficult to do within a small duct, however, and has a relatively large risk of ductal damage; therefore it is not performed frequently [8].

Whenever it is felt that the common bile duct has been cleared of all stones, and no further manipulations are anticipated, it is important to shoot a completion cholangiogram documenting the free flow of contrast through the common bile duct into the duodenum, in addition to no new abnormalities in anatomy.

If a transcystic approach was used, the cystic duct needs to be ligated with clips and divided. If a choledochotomy was performed, it can be closed primarily with no drainage, or a biliary stent (T-tube), placed into the duodenum through the choledochotomy, can be used to protect the primary repair. Closure with T-tube drainage is the preferable and safer closure. The indications for T-tube drainage are [8]:

Decompression of the common bile duct if outflow obstruction due to residual stones or edema
Ability to obtain T-tube cholangiogram for postoperative visualization of ducts
Access for removal of residual stones

To place the T-tube, a small section of the back of the T is cut out, and the T-tube is placed into the common duct through the choledochotomy. The remainder of the common bile duct opening then is closed with a 4-0 or 5-0 absorbable suture with intracorporeal laparoscopic suturing and knot tying. It is important to use absorbable suture, because other sutures can be lithogenic. After placement of the T-tube, which is brought out through one of the trocar sites, a completion cholangiogram must be performed. The T-tube is tested by pushing fluid through it and verifying there is no leak. If a T-tube is not going to be used, the entire choledochotomy is closed primarily with the same suture. A T-tube cholangiogram is obtained before removing the tube 2 weeks after surgery.

The risks of T-tube placement include increased morbidity or mortality secondary to biliary infection, migration of the tube causing bile duct obstruction, or bile duct leaks or peritonitis after removal. To prevent the latter two complications, the T-tube must not be pulled up tightly to the abdominal wall, and the T-tube must not be removed for at least 2 weeks postoperatively. A 2007 Cochrane review found insufficient evidence to recommend T-tube drainage over primary closure or vice versa [26].

Laparoscopic common bile duct exploration has a high success rate, with rates reported from 83% to 96% in recent years (93.3% in 2008 Cochrane Review) [9]. The morbidity rate has been reported to be approximately 10% and includes minor complications such as: nausea, vomiting, diarrhea, fever, and urinary retention. Major complications, defined as those that require further procedures, include: wound infections, biliary leaks, abscess formation, subhepatic fluid collections, T-tube complications, and pulmonary, cardiac, or renal failure. Mortality rates are very low, at less than 1%.

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