

Management of Large Common Bile Duct Stones: Review Article

Mohamed Suliman Ibrahim Alayeb¹, Wael Salah El-din Mansi², Mohamed Farouk Amin² and Mohamed Adel Ahmed Saleh²

¹General Surgery Department, Faculty of Medicine - Benghazi University – Libya

²General Surgery Department, Faculty of Medicine, Zagazig University, Egypt

***Corresponding author:** Mohamed Suliman Ibrahim Alayeb

Abstract:

Large common bile duct (CBD) stones present significant therapeutic challenges due to their size, composition, and associated complications. Advances in endoscopic, surgical, and lithotripsy techniques have broadened the management options, with individualized treatment strategies tailored according to stone size, number, patient comorbidities, and available expertise. This paper reviews the current approaches to the management of large CBD stones, emphasizing endoscopic retrograde cholangiopancreatography (ERCP), lithotripsy, peroral cholangioscopy, and surgical interventions, along with recent technological innovations that enhance success rates and safety.

Keywords: Common bile duct stones; Choledocholithiasis; Large stones; Endoscopic retrograde cholangiopancreatography (ERCP); Lithotripsy; Cholangioscopy; Biliary surgery; Stone clearance.

Introduction:

Choledocholithiasis, the presence of stones in the common bile duct (CBD), remains a significant clinical problem, especially when stones are large in size. Large CBD stones (>15 mm) are difficult to extract with standard endoscopic techniques and are associated with higher rates of complications such as cholangitis, biliary obstruction, and pancreatitis. Early diagnosis and appropriate management are crucial to prevent long-term morbidity and mortality (1).

Endoscopic retrograde cholangiopancreatography (ERCP) with sphincterotomy is considered the gold standard for the management of CBD stones; however, its effectiveness decreases as the stone size increases. To overcome these challenges, adjunctive methods such as mechanical lithotripsy, large balloon dilation, and cholangioscopy-guided lithotripsy have been introduced, providing improved clearance rates for large and difficult stones (2).

When endoscopic clearance fails or is not feasible, surgical approaches, including laparoscopic common bile duct exploration (LCBDE) and open choledochotomy, remain valuable alternatives. With advances in minimally invasive surgery and the availability of advanced endoscopic tools, the treatment strategy for large CBD stones is increasingly individualized, taking into account stone size, patient comorbidities, and available expertise (3).

The mainstay treatment for choledocholithiasis is endoscopic stone removal via ERCP, which involves duodenoscope-guided access to the common bile duct, sphincterotomy, and stone extraction using baskets, snares, or balloon catheters (4). Management of choledocholithiasis may require lithotripsy techniques (mechanical, electrohydraulic, or laser via cholangioscopy) for large or difficult stones (5).

ERCP with Sphincterotomy and Balloon/Basket Extraction in the Management of Common Bile Duct Stones

Endoscopic Retrograde Cholangiopancreatography (ERCP) is the standard approach for diagnosing and managing choledocholithiasis, with sphincterotomy followed by stone extraction using balloon catheters or baskets being the most common technique. This method is highly effective, minimally invasive, and serves both diagnostic and therapeutic purposes in a single procedure (6).

- **Endoscopic Sphincter**

Endoscopic sphincterotomy (EST) involves incision of the sphincter of Oddi with an electrosurgical sphincterotome to widen the ampulla of Vater, facilitating bile duct stone removal and improving biliary drainage (7). It allows spontaneous or assisted stone passage, reduces biliary pressure, and relieves obstruction or cholangitis. While generally safe in experienced hands, risks include bleeding, perforation, and pancreatitis, particularly in high-risk patients or those with coagulopathies (8).

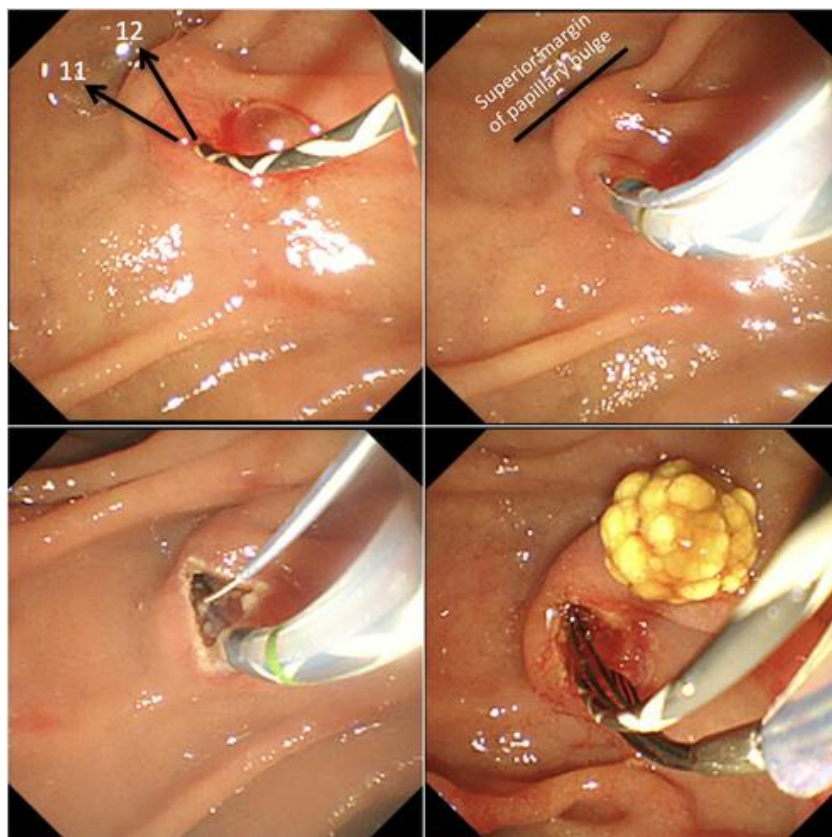


Fig (1): Illustration of biliary sphincterotomy technique- the direction of biliary sphincterotomy at between 11 and 12 o' clock and the superior margin of the papillary bulge marks the maximum extent of a safe cut (9).

- **Balloon Catheter Extraction**

After sphincterotomy, balloon catheters are commonly used to clear CBD stones by inflating the balloon beyond the stone and sweeping it into the duodenum. This method is especially effective for small to medium, mobile stones, offering simplicity, low risk of ductal injury, and short procedure time (10). Balloons come in various sizes, allowing adjustment to ductal anatomy, with clearance typically performed in a stepwise approach, starting with smaller balloons and escalating if needed (11).

- **Dormia Basket Extraction**

The Dormia basket is used to capture and extract CBD stones, making it especially useful for larger, impacted, or balloon-resistant stones (12). It allows controlled retrieval and can navigate strictures or angulated ducts. However, complications such as basket impaction may occur, sometimes requiring lithotripsy or surgery, so this technique is generally reserved for cases where balloon extraction fails or is unsuitable (13).

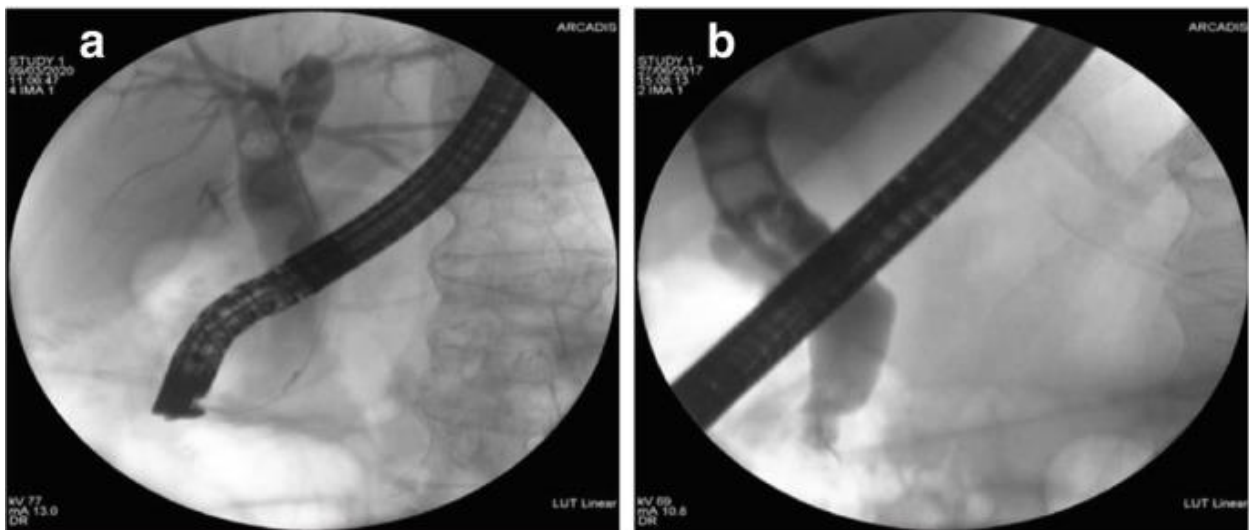


Fig (2): demonstrates cholangiographic images of choledocholithiasis obtained during ERCP. In part (a), a solitary stone appears as a contrast filling defect near the hepatic hilum. In part (b), multiple faceted stones are seen in the mid-portion of the choledochus. These radiologic appearances are typical of stones visualized during contrast-enhanced fluoroscopic imaging in ERCP (14).



Fig (3): provides endoscopic visualization of stones extracted into the duodenum. In part (a), a stone is visible at the major duodenal papilla following balloon extraction. In part (b), multiple stones are seen post-retrieval, confirming successful ductal clearance (14).

- **Efficacy and Outcomes**

Endoscopic sphincterotomy with balloon or basket extraction achieves high clearance rates of 85–95% on first attempt. Success is influenced by stone size (>15 mm), number, anatomical variations, and strictures (15). While most stones can be removed without adjunctive methods, difficult cases may require mechanical lithotripsy, cholangioscopy-assisted lithotripsy, or large balloon dilation (16).

- **Complications**

ERCP with EST and stone extraction, though effective, carries risks. The most common complication is post-ERCP pancreatitis (3–15%), followed by bleeding, especially in anticoagulated patients, and cholangitis from incomplete clearance or contamination. Rarely, perforation occurs and may require surgery (17). Complication rates can be reduced through careful patient selection, prophylactic pancreatic stenting, rectal NSAIDs, and meticulous technique (18).

Sphincteroplasty

Sphincteroplasty, also referred to as endoscopic papillary balloon dilation (EPBD) or endoscopic papillary large balloon dilation (EPLBD), is an endoscopic procedure used to enlarge the opening of the bile duct at the ampulla of Vater. It is typically performed during endoscopic retrograde cholangiopancreatography (ERCP) to facilitate the removal of large or difficult common bile duct (CBD) stones. This technique serves as an alternative or adjunct to traditional endoscopic sphincterotomy (EST), especially in cases where complete sphincterotomy is contraindicated or insufficient for stone extraction (19).

- **Indications**

Sphincteroplasty is primarily indicated in patients with large bile duct stones, typically those greater than 15 mm in diameter, or in patients with multiple, barrel-shaped, or impacted stones that are unlikely to pass through a nondilated sphincter. It is also especially useful in patients who are at high risk of bleeding, such as those with coagulopathies or those on antithrombotic medications, where a full sphincterotomy might pose excessive bleeding risk. Additionally, sphincteroplasty can be beneficial in patients with altered surgical anatomy, such as those who have undergone Billroth II gastrectomy or Roux-en-Y gastric bypass, where conventional access to the bile duct and papilla is technically challenging (20).

- **Technique**

During ERCP, balloon dilation of the sphincter of Oddi is performed after CBD cannulation. A balloon (12–20 mm) is inflated under fluoroscopic guidance for 1–5 minutes to enlarge the ampullary orifice (Bourke, 2024). Often, a limited sphincterotomy precedes dilation to ease passage and lower pressure. The aim is to widen the opening sufficiently for spontaneous or assisted stone extraction with balloons, baskets, or other devices (21).

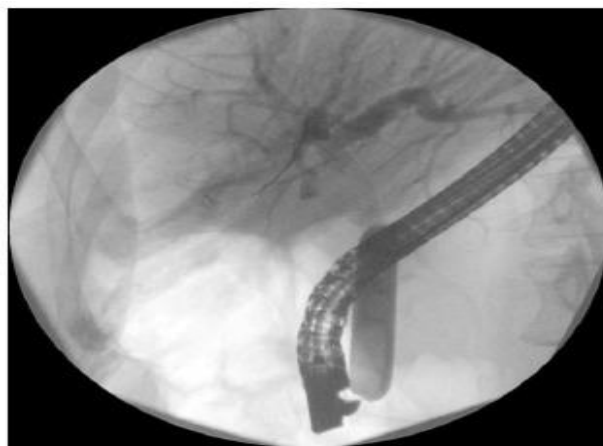


Fig (4): Large diameter papillary balloon dilatation to remove bile duct stone (22).

- **Advantages**

One of the main advantages of sphincteroplasty over traditional sphincterotomy is its preservation of sphincter function, which may reduce long-term complications such as duodenobiliary reflux or recurrent stone formation. It also carries a lower risk of bleeding, making it a safer option for elderly patients and those with underlying bleeding disorders. Furthermore, the technique has been shown to have a high success rate in achieving ductal clearance, particularly when used in conjunction with other techniques like mechanical lithotripsy or cholangioscopy-guided stone fragmentation (23).

- **Risks and Limitations**

Despite its benefits, sphincteroplasty is not without risks. The most significant complication associated with the procedure is post-ERCP pancreatitis. This is thought to result from inadequate loosening of the sphincter of Oddi, papillary edema, or compression of the pancreatic duct caused by mucosal hemorrhage or inflammation following balloon dilation. The risk can be mitigated by ensuring optimal balloon size and duration of dilation, typically using longer inflation times (around 5 minutes) to allow gradual and effective dilation of the papilla.

Other complications include perforation, papillary tearing, and bile duct injury, although these are relatively rare when performed by experienced endoscopists (24).

Cholangioscopy-Guided Laser Lithotripsy

Cholangioscopy-guided lithotripsy is a valuable endoscopic technique used for the management of difficult or large common bile duct (CBD) stones, especially when conventional methods such as sphincterotomy and mechanical lithotripsy are ineffective. This method involves the direct visualization of bile duct stones and targeted lithotripsy using electrohydraulic lithotripsy (EHL) or laser lithotripsy (LL), which can precisely fragment stones under direct endoscopic control (25).

- **Traditional Cholangioscopy Systems**

Historically, cholangioscopy was performed using a dual-scope system, commonly referred to as the "mother-baby" scope system. In this setup, a standard duodenoscope (mother scope) allows insertion of a smaller cholangioscope (baby scope) through its accessory channel into the bile duct. The baby scope is equipped with its own working channel, through which lithotripsy probes (EHL or LL) are introduced (26).

While effective, this technique is technically demanding. It requires two experienced endoscopists, one to manage each scope, and is limited by the baby scope's restricted two-way steering and fragile build, which increases the risk of damage and high repair costs. Furthermore, complex biliary anatomy or sharp ductal angulations may impede access to intrahepatic or cystic ducts, reducing the success rate in certain patients (27).

- **SpyGlass Direct Visualization System**

The SpyGlass Direct Visualization System was developed as a single-operator cholangioscopy platform to simplify bile duct stone management. It provides four-way steering, irrigation channels, and a working channel for therapeutic interventions such as laser lithotripsy (28). Compared to earlier fiber-optic models, newer digital versions offer higher image resolution, enabling improved stone visualization and procedural precision (29).

In practice, the cholangioscope is advanced through a duodenoscope, allowing direct positioning of the laser fiber near the stone for precise fragmentation. This technique is particularly valuable in managing large, impacted, or intrahepatic stones, failed standard endoscopic cases, and in patients with altered anatomy or high bleeding risk. Direct visualization reduces ductal injury and improves clearance (8).

Despite its advantages, limitations include high equipment costs, limited availability, procedural complexity, and the need for expertise. Potential complications such as cholangitis, hemobilia, and bile duct injury, although uncommon, remain concerns (30).

- **Direct Peroral Cholangioscopy (DPOC)**

Direct peroral cholangioscopy (DPOC) involves advancing an ultraslim upper endoscope through the biliary sphincter directly into the bile duct for direct visualization. With the development of high-definition ultraslim endoscopes featuring narrow band imaging, DPOC has gained popularity due to its many advantages (31).

Compared to using dedicated cholangioscopes, DPOC offers benefits such as being a single-operator procedure, providing superior digital image quality, and allowing simultaneous irrigation and therapeutic interventions. However, a significant challenge is successfully navigating the biliary sphincter, as the ultraslim endoscope tends to form loops in the stomach or duodenum, complicating bile duct entry. To improve success, specialized accessories and techniques are often needed to advance the endoscope into the proximal biliary system (31).

DPOC, various techniques aid ultraslim endoscope access. A guidewire can help maintain biliary entry but may dislodge or form loops (32). Alternatives include an intraductal balloon to pull the scope into the biliary tree, though stability is lost once removed, and an overtube balloon, which is limited by its large size and maneuverability issues (33).

A newer anchoring balloon device improves access distal to the hepatic confluence, though looping remains a challenge (34). Rare but serious complications such as air embolism must be considered. Once inside, laser or electrohydraulic lithotripsy probes can be used under direct visualization, enabling effective stone fragmentation, even in cases refractory to standard therapies. Ultrathin endoscopes are continually evolving, with transnasal approaches also proving successful for stone extraction (7).

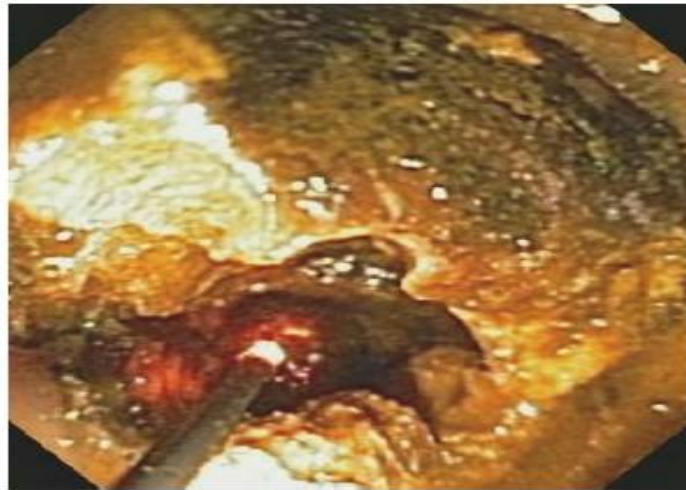


Fig (5): Direct peroral cholangioscopy guided laser lithotripsy of a bile duct stone. The red laser light makes targeting of the stone easier (22).

Bile Duct Stone Dissolution

Bile duct stone dissolution was historically explored for patients unfit for surgery or endoscopic extraction, using nasobiliary catheter infusion of chemical agents (35). Mono-octanoic acid was the most studied and showed some efficacy for cholesterol stones, while MTBE had limited use due to side effects, and EDTA/bile acid solutions were investigated for calcium-containing stones (36).

However, complete dissolution was uncommon, with agents mainly softening or reducing stone size to aid later removal. Given the low success rates, frequent adverse effects such as diarrhea and duodenitis, and poor clinical outcomes, chemical dissolution has been largely abandoned and is no longer recommended (37).

Biliary Endoprotheses

Biliary stenting is an established option for patients unfit for surgery or prolonged endoscopic procedures, particularly the elderly or those with comorbidities. It maintains bile drainage in cases of large or difficult stones, preventing obstruction and complications (38). Plastic stents, usually double pigtail (7Fr) or larger straight types (10–11.5Fr), are placed above the stones, though technical difficulty may arise with distal CBD stenosis or altered anatomy (39).

Prolonged stenting (3–6 months) can fragment or reduce stones, occasionally leading to complete disappearance (40). However, risks include occlusion, cholangitis, and the need for repeated ERCP for stent exchange or removal. Multiple pig-tail stents may improve outcomes and reduce complications compared to single stents (41). Careful monitoring remains essential due to possible adverse events such as cholangitis or pancreatitis (42).

Surgical Options

Cholecystectomy

The role of cholecystectomy in patients with choledocholithiasis, particularly in the context of large common bile duct (CBD) stones, remains controversial; however, current expert consensus generally supports surgical removal of the gallbladder in most cases. The rationale for performing cholecystectomy lies in the

prevention of recurrent stone formation and associated complications, including cholangitis, pancreatitis, and biliary colic. Nonetheless, individualized risk assessment is critical, especially in populations with significant surgical risk due to advanced age or comorbid conditions. In such patients, conservative management without cholecystectomy may be appropriate if the gallbladder is asymptomatic and no evidence of recurrent biliary disease exists (43).

Cholecystectomy is typically not indicated for primary CBD stones, which form de novo within the ductal system and are often associated with biliary stasis or infection. These cases are managed primarily through ductal stone clearance techniques, rather than removal of the gallbladder (44).

- **Operative Technique**

After induction of anesthesia and intubation, the laparoscopic cholecystectomy may begin. First, insufflation of the abdomen is achieved to 15 mmHg using carbon dioxide. Next, four small incisions are made in the abdomen for trocar placement (supraumbilical x1, subxiphoid x1, and right subcostal x2). Utilizing laparoscope and long instruments the gallbladder is retracted over the liver. This allows for exposure of the proposed region of the hepatocystic triangle. Careful dissection is carried out to achieve the critical view of safety. This view is defined as (1) clearance of fibrous and fatty tissue from the hepatocystic triangle, (2) the presence of only two tubular structures entering into the base of the gallbladder, and (3) the separation of the lower third of the gallbladder from the liver to visualize the cystic plate. Once this view is adequately achieved, the operating surgeon can proceed with confidence of isolation of the cystic duct and cystic artery. Then apply on endoscopic clip distally and two clips proximally, and divide the artery with scissors (Fig. 6). Both structures are carefully clipped and transected (Fig. 7). (45).

Electrocautery or harmonic scalpel is then used to separate the gallbladder from the liver bed completely. Hemostasis should be achieved after the abdomen is allowed to deflate to 8 mmHg for 2 minutes. This technique is employed to avoid missing potential venous bleeding that can be tamponaded by elevated intra-abdominal pressure (15 mmHg). The gallbladder is removed from the abdomen in a specimen pouch. All trocars should be removed under direct visualization (Fig. 8). Closure of port sites is surgeon specific; some authors recommends fascial closure of trocar sites greater than 5 mm to avoid incisional hernias in the postoperative period (46).

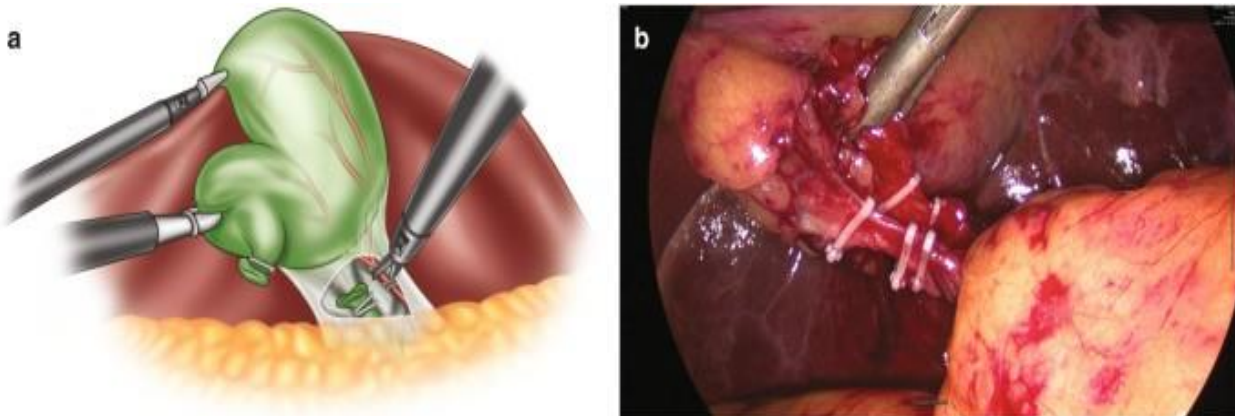


Fig. (6): There are two main types of clips available. A disposable clip applier can be used that deploys metallic clips. The second option is a Weck Hem-o-lok clip which is a plastic polymer clip that is applied using a reusable endoscopic clip applier. The decision of which clips to use is largely based on surgeon's preference and availability. When placing the clip applier around the target structure, ensure the tip of the clip applier can be visualized on the other side before the deploying the clip. It should also be examined to ensure the clip goes all the way across the duct or artery confirming complete occlusion (47).

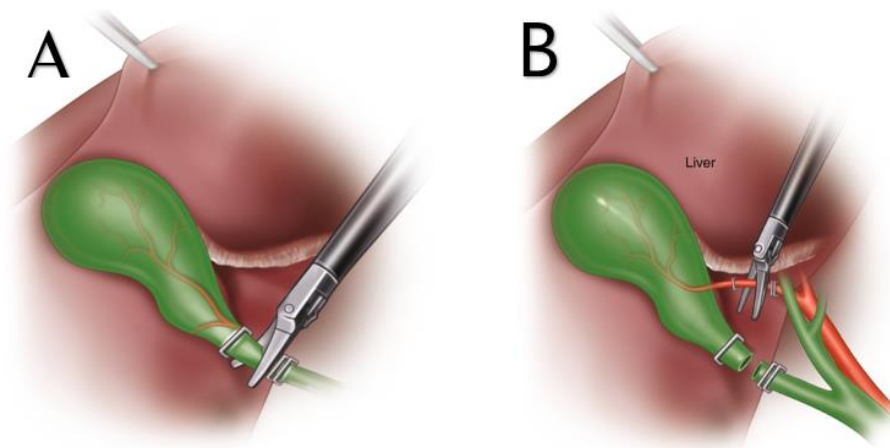


Fig. (7): A. Cystic duct is clipped and is being transected. **B.** Scissors diving the clipped cystic artery (48).

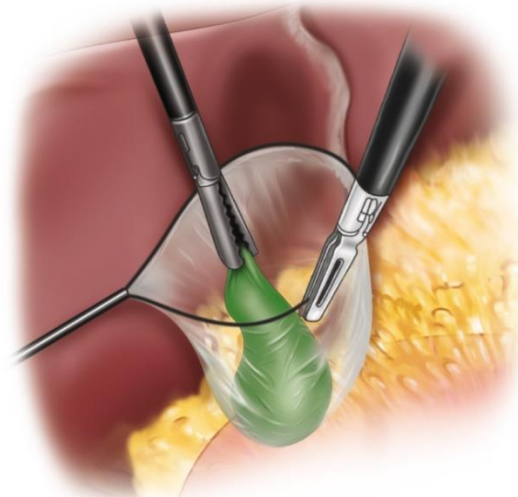


Fig (8): Specimen removal (48).

- **Surgical Considerations in Large CBD Stones**

Patients with large ductal stones may present with distended or fibrotic ducts, inflamed surrounding tissue, or distorted anatomy due to prior inflammation or instrumentation. These factors can increase the technical complexity of both ductal clearance and cholecystectomy.

- When laparoscopic common bile duct exploration (LCBDE) is performed, simultaneous cholecystectomy is typically done in the same session. This one-stage approach offers the advantage of complete biliary clearance and definitive management, avoiding multiple procedures.
- In cases where open choledochotomy is required—often due to impacted, very large, or multiple stones—cholecystectomy is usually performed concurrently.
- Occasionally, a subtotal cholecystectomy may be considered if dissection is hazardous due to severe inflammation or anatomic distortion (49).

- **Considerations in High-Risk Patients**

In elderly or high-risk surgical candidates, the decision to proceed with cholecystectomy following endoscopic clearance of large CBD stones must be individualized. Although conservative management with biliary stenting or observation is sometimes pursued, this strategy carries a higher risk of recurrent biliary obstruction, cholangitis, and the need for repeat interventions. Where feasible, laparoscopic cholecystectomy is still encouraged due to its lower morbidity (50).

Laparoscopic Common Bile Duct Exploration (LCBDE)

Indications of LCBDE:

LCBDE is indicated when common bile duct stones have been demonstrated during patient workup by MRCP, ultrasound (US), or other imaging modalities, or found during intraoperative imaging (cholangiography or ultrasonography). It is also indicated in patients with altered anatomy that would make a traditional ERCP difficult (Roux-en-Y gastric bypass) (51).

Contraindications of LCBDE:

LCBDE is contraindicated in the absence of common bile duct pathology, in patients with hemodynamic instability, or when a hostile porta hepatis is encountered intraoperatively. Furthermore, a lack of technical skill or resources (equipment, personnel) required to perform common duct exploration also contraindicates this procedure (52).

Equipment and resources necessary to perform a LCBDE (53):

Since the specialized instruments for laparoscopic common bile duct exploration (LCBDE) are not routinely used in standard laparoscopic cholecystectomy, surgeons should confirm both availability of the required equipment and team familiarity before starting the procedure. Essential tools include intraoperative fluoroscopy, a 5F cholangiogram catheter with a 0.035-inch guidewire, a 12 Fr vascular sheath, IV glucagon (1–2 mg to relax the sphincter of Oddi), Fogarty-type balloon catheters (4 Fr), and small-diameter stone retrieval baskets (<1 mm) allowing for irrigation during manipulation. Additional equipment may include a high-pressure pneumatic dilator for cystic duct dilation, a flexible choledochoscope (<3.2 mm with a working channel >1.1 mm), irrigation setup, atraumatic forceps, and adequate visualization through either a second camera system or monitor. Closure materials such as absorbable 4-0 or 5-0 sutures for choledochotomy and laparoscopic ligating loops for cystic duct closure are also necessary (53).

The differences in patient positioning and port placement for LCBDE compared with standard laparoscopic cholecystectomy?

For laparoscopic common bile duct exploration (LCBDE), patient positioning mirrors laparoscopic cholecystectomy: supine, reverse Trendelenburg, and right side up to optimize right upper quadrant exposure. The surgeon usually stands on the patient's left, switching to the right for transcystic exploration (54). LCBDE often requires a fifth port in addition to the standard four, typically placed between the subxiphoid and right subcostal ports (24).

The biliary tree evaluation in anticipation of LCBDE:

Intraoperative cholangiography or laparoscopic ultrasonography may be performed to evaluate the biliary tree. This allows assessment of biliary anatomy (size of duct, integrity, anatomic variations, presence of stones) and characterization of the stones themselves (location, size, number). Ultimately, it helps the surgeon make a decision as to the optimal approach for CBD exploration (55). Choledochotomy approach which involves direct incision into the CBD, allowing the extraction of larger, multiple, or impacted stones (56).

Intraoperative cholangiogram (IOC)

Although an IOC with plain X-ray may be performed, dynamic fluoroscopy is strongly encouraged given its utility when performing CBD exploration. Studies have also suggested that it may be more time efficient and accurate. The IOC should be carefully inspected to evaluate the entire biliary tree. Specifically:

- **Cystic duct:** Length, tortuosity, caliber, point of insertion onto CBD.
- **Common bile duct:** Caliber, leak, obstruction, filling defects (stones versus air), contrast flow into the duodenum.
- **Common, right, and left hepatic ducts:** Caliber, leak, obstruction, filling defects (stones versus air), visualization of bifurcation, aberrant right sectional duct anatomy (57).

The right-sided ductal anatomy is important to identify during IOC because of the variability of the sectional ducts. The right anterior sectional duct (segments 5, 8) and right posterior sectional duct (segments 6, 7) should be separately identified. Specifically, the right posterior sectional duct should be clearly defined, as its entry into the central biliary tree is variable, and may insert below the bifurcation, into the cystic duct, into the gallbladder, or into the main left duct, and is vulnerable to injury during cholecystectomy (58).

Failure to identify the right-sided ductal structures should prompt concern for aberrant anatomy or for a possible biliary injury. Stones are suspected when the IOC demonstrates a radio lucent defect, a meniscus, dilation of the biliary tree, or failure of contrast to enter the duodenum (59).

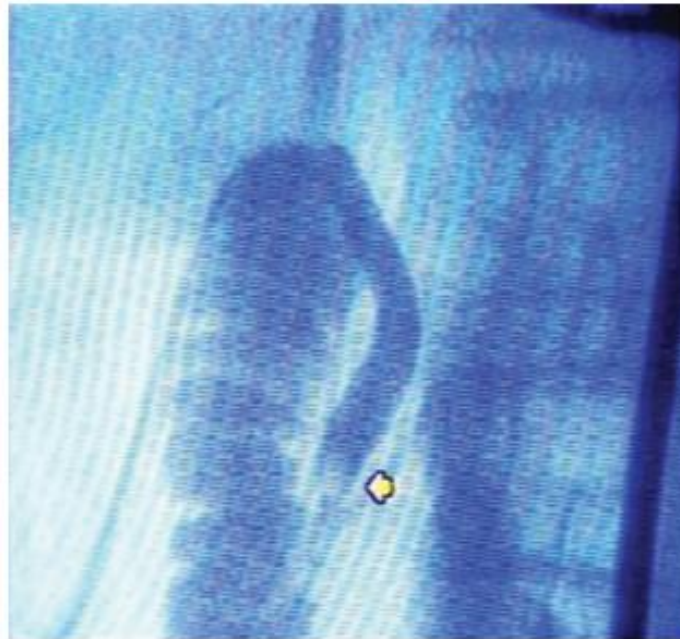


Fig. (9): Intraoperative cholangiogram view showing common bile duct (CBD) stone (60).

Laparoscopic ultrasound

Laparoscopic ultrasound may be performed instead of IOC in determining biliary anatomy, including ductal sizes, stone characteristics, and ampullary and pancreatic head abnormalities that may impact the procedure. The confluence of the right and left hepatic ducts as well as the cystic duct CBD junction may be seen. The CBD is followed to the duodenum to evaluate choledocholithiasis (61).

Fogarty technique

A #4 Fogarty catheter may be used to retrieve the stone. If a guidewire is in place, this should be withdrawn. The catheter is passed into the CBD and beyond the stone. The balloon is inflated and the stone withdrawn through the cystic duct stump by retrieving the catheter. Limitations of the Fogarty technique include the possibility of further impacting the stones into the duodenum through the sphincter of Oddi causing injury, pancreatitis, or bleeding. In addition, the stones may be dragged into the common hepatic duct, making extraction more difficult (62).

Basket retrieval

A stone retrieval wire basket can be utilized to remove the stones under fluoroscopic guidance. Alternatively, this may be performed using biliary endoscopy (63).

Biliary endoscopy

During choledochoscopy in LCBDE, the scope can be advanced into the CBD either over a guidewire (Seldinger technique) or freely after cystic duct dilation (64). Visualization requires a second monitor or picture-in-picture, gentle scope manipulation with atraumatic graspers, and continuous saline flushing (65).

Stones are removed using a retrieval basket introduced through the scope, with repeated passes until clearance is achieved. Final steps include a completion cholangiogram to confirm ductal clearance, closure of the dilated cystic duct, and completion of cholecystectomy (66).

The technique for transcholedochal LCBDE:

When a transcholedochal approach is appropriate, the cystic duct is dissected and followed to the cystic duct CBD junction. The peritoneal layer overlying the anterior surface of the supraduodenal CBD is dissected for approximately 20 mm. A choledochotomy is made longitudinally to avoid injury to the blood supply to the CBD, located at the 3 and 9 o'clock position laterally along the duct. It is often prudent to test for bile first using a free 25-gauge needle prior to cutting to avoid portal venous injury (67).

The incision should be made with an endoknife and/or endoscopic scissors. The length of the incision should equal the diameter of the largest stone. Once the CBD has been entered, the stones will often spontaneously spill out. It is useful to have a specimen retrieval bag in the vicinity to prevent excess spillage. Suction irrigation may be used to flush additional stones. The CBD may be palpated with an atraumatic grasper and stones gently pushed out through the choledochotomy. A choledochoscope or fluoroscopy can be used to evaluate the ducts for residual stones (54).

Choledochotomy allows the choledochoscope to be inserted either proximally into the common, left, and right hepatic ducts or distally into the common duct. A stone retrieval wire basket can be used via the choledochoscope's working channel to retrieve any remaining stones. Once the CBD has been cleared of stones, the ductotomy is approximated with 4-0 or 5-0 absorbable sutures in a running or interrupted fashion. Primary closure, external biliary drain, or biliary stent may be performed at the surgeon's discretion and depending on the clinical situation (68).

Potential Problems During Transcholedochal LCBDE

Impacted stones pose a major challenge as they block retrieval tools; in such cases, laser or electrohydraulic lithotripsy is used to fragment stones for basket removal, with postoperative ERCP as an alternative if unsuccessful (69). Hepatic duct stones may require choledochotomy, but this should be avoided if the CBD is <7 mm due to stricture risk, making ERCP a safer option (70).

When duct clearance is incomplete due to technical issues, edema, or strictures, an antegrade stent can provide temporary decompression and allow elective postoperative ERCP (71). Additional strategies include the laparoscopic–endoscopic rendezvous technique to aid cannulation, while open conversion is reserved for select cases, given its higher morbidity compared to ERCP (72).

Postoperative management after transcholedochal LCBDE:

Oral intake is usually restarted once the patient has recovered from anesthesia and advanced thereafter. If no drain was placed, patients are discharged home within 24 h if there are no other clinical contraindications. If contrast flow into the duodenum is abnormal or stones are present, the drain is left open for 1–2 weeks. Cholangiogram is repeated. If stones are still present, these may be removed via ERCP or with assistance from interventional radiology techniques (73).

Open Choledochotomy

Open choledochotomy is typically reserved for complex or refractory cases, including:

- Failure of ERCP or LCBDE.
- Large or impacted stones not amenable to endoscopic or laparoscopic removal.

- Anatomical abnormalities or prior surgeries that preclude minimally invasive access.
- Severe inflammation or scarring within the porta hepatis (74).

This approach involves a direct incision into the CBD to access and remove stones, usually followed by primary closure depending on the ductal size, inflammation, and completeness of stone clearance (74).

While open surgery is more invasive and associated with longer recovery, it remains a reliable and effective option, particularly when other methods are not viable. In select patients with complex biliary pathology, it provides definitive management and allows for concurrent correction of associated biliary or hepatic abnormalities (75).

- **Indications for Surgical Management**

Surgical options are generally considered in the following scenarios:

- Failed endoscopic or percutaneous interventions.
- Presence of multiple, large (>15 mm), or impacted stones.
- Coexisting biliary tract anomalies or strictures.
- Intraoperative discovery of CBD stones during cholecystectomy.
- Patients with altered anatomy (e.g., post-gastric surgery) limiting ERCP access (76).

- **Procedure**

The procedure typically begins by identifying and ligating the proximal portion of the cystic duct. This step is crucial to prevent backflow of bile and any dislodged stones from the gallbladder into the common bile duct during the exploration process. Proper ligation also helps isolate the biliary system, reducing the risk of bile leakage and providing a clearer field for the choledochotomy. The cystic duct is usually doubly ligated and divided in preparation for open exploration of the CBD (77).

Once the cystic duct is secured, a longitudinal incision is made on the anterior surface of the common bile duct. This choledochotomy is usually about 1.5 cm in length and is placed just above the duodenum, where the CBD is most accessible. The longitudinal orientation of the incision minimizes the risk of postoperative stricture formation and provides sufficient access to retrieve stones. It also facilitates easier closure and reduces tension across the suture line (78).

To maintain adequate exposure and patency of the choledochotomy during the exploration, stay sutures are placed on either side of the incision. These sutures help to retract the bile duct wall and keep the incision open, allowing instruments or a choledochoscope to be introduced without collapse of the duct. Stay sutures provide better visualization of the lumen and make the retrieval of stones more efficient and controlled (79).

Initial efforts to remove common bile duct stones often involve manual expression by gently milking the duct. If stones cannot be removed manually, a Fogarty or balloon catheter is inserted through the choledochotomy and passed downstream toward the ampulla of Vater. The balloon is inflated and then gently withdrawn, bringing stones back through the incision (80).

If this method fails, a choledochoscope may be introduced to visualize the stones directly. Under direct vision, a wire basket can be guided through the working channel of the scope to snare and extract the stones. This method allows retrieval of deeply impacted or proximally located stones that cannot be reached by a balloon catheter alone (80).

Once exploration is complete, the choledochotomy is typically closed using interrupted or continuous absorbable monofilament sutures, such as polydioxanone (PDS). These sutures reduce the risk of stone formation and inflammation compared to braided sutures. Meticulous technique is critical to avoid narrowing of the bile duct lumen, which could lead to stricture formation. The closure should be tension-free and watertight to prevent postoperative bile leaks (81).

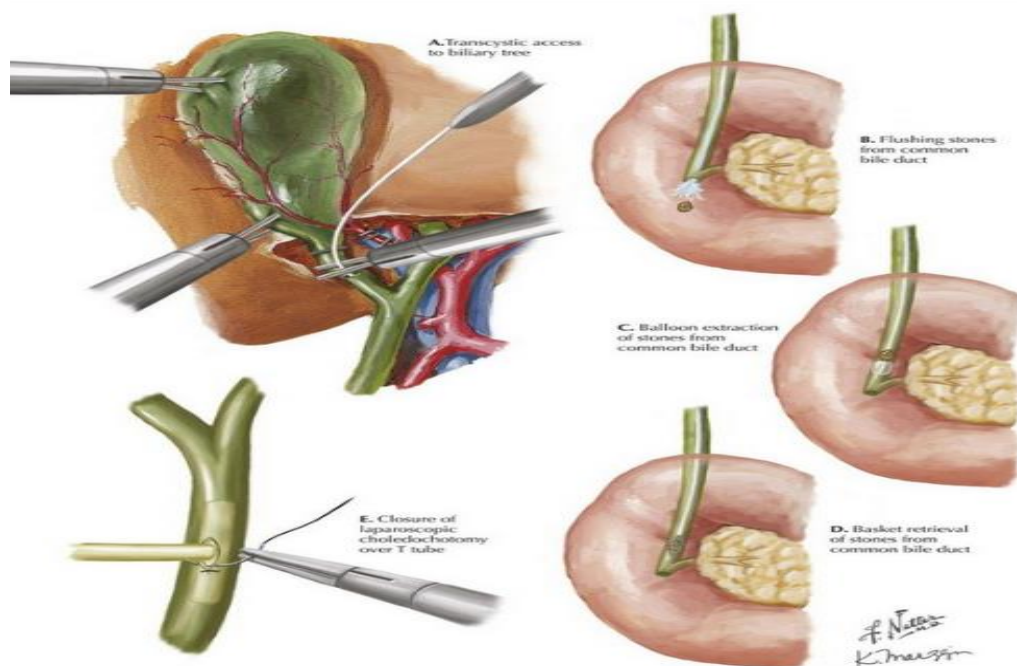


Fig. (10): Technical schematic of open choledochotomy: (A) Right subcostal incision with Kocher maneuver exposing CBD, (B) Longitudinal incision into CBD, (C–D) Stone retrieval via irrigation, balloon, or wire basket under choledochoscopic guidance, (E) primary closure after complete clearance (82).

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