Trauma Surgery & Acute Care Open

Reclaim the duct! Laparoscopic common bile duct exploration for the acute care surgeon

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The 2025 Annual Trauma, Critical Care, and Acute Care Surgery Conference, Las Vegas, NV

Received 20 February 2025
Accepted 1 April 2025

To cite: Cironi K, Martin MJ. *Trauma Surg Acute Care Open* 2025;**10**:e001821.

ABSTRACT

Laparoscopic common bile duct exploration (LCBDE) has emerged as a viable and effective alternative to the traditional multistage management of choledocholithiasis involving preoperative or postoperative endoscopic retrograde cholangiopancreatography (ERCP). Despite its advantages, LCBDE remains underused, particularly among trauma and acute care surgeons, due to its technical challenges and limited training opportunities. This practical review examines advancements in LCBDE technology, exploring its clinical applications, outlining key steps for its successful implementation, and evaluating selected current literature. Multiple studies have demonstrated that LCBDE achieves comparable success rates to ERCP and reduces hospital length of stay, overall costs, and the need for additional procedures. However, barriers to widespread adoption persist, primarily related to the technical learning curve, limited exposure during surgical training, and institutional workflow constraints favoring ERCP. With recent advancements in surgical technology and enhanced training models, LCBDE is becoming increasingly adoptable. Given their frequent management of biliary abnormality, trauma and acute care surgeons should develop proficiency in this technique to optimize patient outcomes and minimizing procedural burden.

INTRODUCTION

The continuous evolution of surgical techniques and technologies has played a fundamental role in advancing the field of surgery, leading to significant reductions in morbidity and mortality across many surgical procedures and specialties.[1 2] Among these advancements, laparoscopy and other minimally invasive surgical (MIS) techniques represent one of the most transformative developments in the past 50 years. These techniques have not only enhanced surgical techniques but have improved patient outcomes. Although laparoscopy was first described in the early 1900s, it was not widely adopted by general surgeons until the 1980s, after the success of the modern laparoscopic cholecystectomy.[2] This milestone triggered a rapid shift towards MIS approaches, leading to continuous innovation in technology and equipment that now facilitates minimally invasive applications across nearly all known or described operations.

One such technique is the laparoscopic common bile duct exploration (LCBDE).

Choledocholithiasis, the presence of stones in the common bile duct, is a relatively common condition, affecting approximately 10–15% of patients undergoing a cholecystectomy.[3–7] Managing choledocholithiasis includes various stone extraction approaches, such as preoperative, intraoperative, or postoperative endoscopic retrograde cholangiopancreatography (ERCP), intraoperative cholangiography with flushing of the duct, or LCBDE.[8]

LCBDE offers the advantage of allowing a single surgical team to perform both stone extraction and laparoscopic cholecystectomy within the same operation, eliminating the need for separate interventions and reducing reliance on additional healthcare teams. Although ERCP has gained widespread use in recent decades, the combined LCBDE and cholecystectomy approach has demonstrated several advantages, including lower overall costs, reduced hospital stays, decreased rates of postoperative bleeding, and lower incidence of pancreatitis.[9–11]

Given that trauma and acute care surgeons frequently manage patients with choledocholithiasis, a thorough understanding of LCBDE is essential. In this review, we aim to provide a focused, practical overview of our approach to LCBDE, including clinical applications, advantages, and technical considerations for the procedure. Additionally, we outline several recommendations for supporting surgical education and training when learning LCBDE box 1. This review emphasizes the particular approach and techniques used by the authors and their center, and is not meant to be an exhaustive review of the literature or a broad review of all available techniques or approaches to LCBDE.

DISCUSSION

MIS in trauma and acute care surgery

Although many general surgeons have rapidly integrated MIS techniques into their practice, the field of trauma and acute care surgery (ACS) has been slower to adopt these advancements. Historically, trauma surgeons have demonstrated less enthusiasm towards MIS techniques, largely due to both real and perceived limitations in managing emergent abdominal diseases and injuries. Although the adoption of MIS techniques within trauma and ACS has increased in recent years, the specialty continues to lag behind others in fully embracing and using this technology to its full potential.[12]

The reasons for this are multifactorial. MIS applications in the management of truly emergent or life-threatening conditions remain limited, and the technology has yet to match the speed and ease of open surgery in critical situations. Additionally, there has been a general reluctance among trauma surgeons to abandon well-established, traditional

Box 1 Top 10 tips: adopting laparoscopic common bile duct exploration (LCBDE) in acute care surgery.

1. Be wary of experts telling you that LCBDE is a 'simple' and 'easily adopted' surgical technique. Successful adoption requires dedication, time investment, and a learning curve.
2. However, it CAN be adopted by any acute care surgeon willing to invest the time and effort.
3. Don't go it alone (if possible)—adoption is always easier if you have at least one or two partners who will go through the process with you, or a partner already skilled in LCBDE to mentor you.
4. The technology and equipment for LCBDE has advanced significantly over the past 5 to 10years, with a resultant decrease in the learning curve and frustration levels during the early experience phase.
5. Create a local protocol or algorithm that funnels all appropriate patients into your LCBDE pathway.
6. Meet with your local industry rep to review the LCBDE equipment at your facility and get hands-on training with a simulator. Set up a case observation with a surgeon who does LCBDE if possible.
7. Start by performing routine intraoperative cholangiography (IOC) on all cases and get comfortable with initial duct access and catheter and/or wire placement.
8. Getting and maintaining 'deep wire access' (wire through cystic duct and into duodenum) is the key to a successful LCBDE (transcystic approach). Getting wire access is the most common struggle and may require several different techniques if you are unable to pass the wire initially.
9. Know the indications and contraindications to transcystic CBDE and stone extraction, and the adjuncts that may be required (crushing stones, lithotripsy, balloon sphincteroplasty) if simple transcystic stone extraction is not possible.
10. Choledochotomy and direct CBDE is an option for complex cases but should be limited to those with a significantly dilated CBD and surgeon comfort with laparoscopic suture closure of the ductotomy.

BONUS (and most important) Tip

11. In difficult cases, it is perfectly acceptable to 'bail out' of the LCBDE and perform the cholecystectomy only with plans for postop ERCP or PTC.

CBD, common bile duct; ERCP, endoscopic retrograde cholangiopancreatography; PTC, percutaneous transhepatic cholangiography.

operative techniques in favor of new approaches, although this is rapidly evolving due to the increased MIS exposure and comfort among general surgery trainees and the coverage of more urgent/emergent general surgery conditions in the ACS paradigm.[12] When analyzed through the lens of technology adoption models (figure 1), trauma surgeons often fall into the "Late Majority" or "Laggards" categories, indicating a tendency to adopt innovations at a slower rate than their counterparts in other surgical specialties.[13] In response to this, there have been numerous recent programs by major trauma organizations such as the American Association for the Surgery of Trauma and the Eastern Association for the Surgery of Trauma to increase educational programs in advanced laparoscopy, endoscopy, and robotics aimed at both ACS fellows and currently practicing attending surgeons.

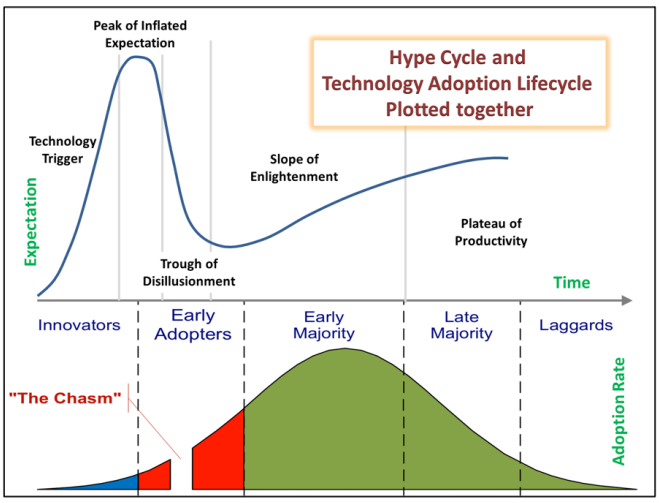

Figure 1 The cycle of adaptation to technology over time[13]

Algorithm for suspected choledocholithiasis

Patients with suspected choledocholithiasis often present with right upper quadrant pain and elevated liver enzymes. A diagnosis is suggested when there is laboratory evidence of biliary obstruction (elevated alkaline phosphatase and direct bilirubin) and/or dilation of the common bile duct seen on initial imaging. In addition to this indirect evidence, imaging studies such as ultrasound, CT, or MRI may provide a definitive diagnosis by visualizing a stone in the CBD.[14] Finally, diagnosis may be confirmed intraoperatively with either cholangiography or intraoperative ultrasound of the CBD.[15]

In cases where a patient presents with acute cholangitis or biliary obstruction with concurrent acute pancreatitis, preoperative ERCP followed by cholecystectomy is often the preferred management strategy. For patients without clinical evidence of cholangitis or biliary obstruction with pancreatitis, management options include preoperative ERCP, intraoperative CBD exploration, or intraoperative or postoperative ERCP.[14] If a patient presents with right upper quadrant pain but no evidence of biliary obstruction or CBD stone on imaging, cholecystectomy alone is typically sufficient.[14]

Transcystic versus trans-choledochal common bile duct exploration

In general, there are two distinct approaches or main technical categories for LCBDE, although they can be thought of as options along a continuum that are applied in specific situations and that require specific skill sets to perform safely and effectively. Transcystic CBDE is the standard default approach used in most patients as it can be readily performed in combination with intraoperative transcystic cholangiography and does not require direct exposure or instrumentation of the CBD. This typically involves establishing wire access through the cystic duct and into the CBD and duodenum (if possible) and then exploration and removal of any CBD stones using either choledochoscopy (direct visualization) or fluoroscopic-guided CBD clearance via flushing and passage of instruments such as wire baskets or Fogarty balloon catheters to remove the obstructing CBD stones. Our preferred approach is via direct visualization with transcystic choledochoscopy which is described in further detail in the following sections, but an understanding of the alternative techniques is important to optimize the chances of a successful CBDE.

Transcholedochal CBDE is an important but less commonly performed technique that requires a higher level of minimally invasive surgery technique and that is only used in several specific situations. It is typically performed by surgeons with advanced minimally invasive surgery or hepatobiliary training but can be safely adopted by any acute care surgeon with appropriate training and laparoscopic suturing skills. The transcholedochal approach is typically used as a "step-up" procedure if a transcystic approach cannot be performed or fails to remove the CBD stones, in cases where the CBD stones are too large for transcystic extraction, or in patients who have had a prior cholecystectomy, and the cystic duct cannot be safely identified and used for access. Additional details of this technique are provided in the subsequent sections. As opposed to the transcystic CBDE where there is no dissection or direct instrumentation of the CBD, transcholedochal CBDE requires dissection and exposure of at least the anterior surface of the CBD and making a choledochotomy for direct CBD access and instrumentation. This does add the additional risks of injury to the CBD or the right hepatic artery and bile leaks or strictures related to the choledochotomy closure. However, several series have reported low rates of additional complications with this approach versus transcystic techniques.[4 8 10]

Notably, there is also an option to dilate the cystic duct to remove CBD stones before having to "step up" to the above-mentioned transcholedochal approach. This is useful in the setting of large stone extraction. Surgeons make a laparoscopic transcystic dilation of the cystic duct confluence with separation forceps or balloon dilation, thus avoiding a CBD incision. One study analyzed 68 patients who underwent cystic duct confluence dilation. 91% were successfully treated, 4% were converted to open cholecystectomy due to extensive fibrosis, and 4% converted to transcholedochal CBDE.[16] This technique is a viable option for the removal of large CBD stones; however, more research is recommended to better elucidate its benefits and risks for CBD stenosis.

Patient selection and indications for LCBDE

Appropriate patient selection is crucial for ensuring a successful and low-stress LCBDE, particularly for surgeons early in their learning curve. Patients with severe acute cholecystitis, multiple CBD stones, altered anatomy, high body mass index, hepatomegaly, or cirrhosis should generally be reserved for surgeons with more experience in LCBDE as these conditions can significantly complicate the procedure. Additionally, because LCBDE typically extends operative time by at least an hour, it may not be suitable for patients with severe comorbidities or acute critical illness who may not tolerate prolonged anesthesia. All patients should be counseled on specific risks of the LCBDE prior to surgery, including wound infection, biliary leak, biliary stricture, bleeding, pancreatitis, potential injury to adjacent structures (duodenum, colon, liver, adjacent major vessels), and the inherent risks for general anesthesia.

The ideal candidate for LCBDE, particularly for surgeons first learning this operation, is a patient with symptomatic, confirmed choledocholithiasis, a dilated CBD, and a single, distally located stone without evidence of additional CBD or proximal hepatic duct stones. These characteristics can be identified using preoperative imaging and/or intraoperative cholangiogram (IOC). Patient-specific factors will also analyze the feasibility of transcystic versus transcholedochal CBD exploration table 1.[17]

As the surgeon gains comfort and familiarity with LCBDE, more complex cases can be attempted. These may include patients with multiple bile duct stones, large stones unsuitable for transcystic extraction, short cystic ducts, anatomic variations, or those with altered gastrointestinal anatomy (eg, prior Roux-en-Y gastric bypass), which can render standard ERCP challenging.[8] All patients undergoing LCBDE should be thoroughly counseled on the risks of the procedure, including biliary tree injury, failure to achieve complete stone clearance, and the potential need for additional interventions, such as ERCP, percutaneous transhepatic cholangiography, or open surgical exploration.

Table 1 Factors that can influence the approach to LCBDE[17 35]

Factor	Transcystic	Transcholedochal
One stone	+	+
Multiple stones	+	+
Stones ≤6 mm diameter	+	+
Stones>6 mm diameter	–	+
Intrahepatic stones	–	+
Diameter of cystic duct<4 mm	–	+
Diameter of cystic duct>4 mm	+	+
Diameter of common duct<6 mm	+	–
Diameter of common duct>6 mm	+	+
Cystic duct entrance to CBD-lateral	+	+
Cystic duct entrance to CBD-posterior	–	+
Cystic duct entrance to CBD-distal	–	+
Inflammation-mild	+	+
Inflammation-marked	+	–
Suturing ability-poor	+	–
Suturing ability-good	+	+

Improved or equivocal likelihood for success = +, Poor likelihood for success for sucess = –.
CBD, common bile duct; LCBDE, laparoscopic common bile duct exploration.

How we do it: supplies and technique

There are numerous techniques, devices, and supplies currently available for performing LCBDE. In this review, we describe the current system and techniques we use; this may differ from other surgeons and centers, and the exact details of supplies, equipment, techniques, and sequence should be adapted to the individual surgeon or service. To start, most importantly, one must find the equipment and techniques that work best for them and their practice or patient population. These cases may occur at any hour of the day and require a significant number of supplies and resources. The key to streamlining your LCBDE cases and having everything you need available is to create a dedicated cart or storage area where all of the supplies and equipment are located. These supplies are outlined in box 2.

Technique for standard transcystic LCBDE

1. Place cholangiocatheter via cystic ductotomy and perform IOC to confirm CBD stones are present.
2. If IOC is positive, then proceed with transcystic LCBDE.
   a. If only small stones are visualized, then one can attempt to flush stones through the ampulla.
3. Pass a 0.035-inch guidewire through the cholangiocatheter into the CBD and, if able, into the duodenum.
4. Remove the cholangiocatheter and pass a 6 mm cystic duct balloon dilator into the cystic duct under direct visualization. Inflate the balloon with saline and hold in place for 60 seconds ×2. If further dilation is required, then one can upsize to an 8 mm balloon.

Box 2 Equipment recommended when performing an LCBDE.[36 37]

1. Intraoperative fluoroscopy (eg, C-arm)
2. EHL Autolith Generator: electrohydraulic lithotripsy device and lithotripsy probe
3. Spyglass Discover controller base and light source[36]
4. Spyglass Digital choledochoscope[37]—single-use disposable choledochoscope

*Tip: requires pressured saline to be continuously owing during choledochoscopy to allow for duct distension and visualization

5. Cholangiocatheter—catheter must allow for a 0.035-inch wire to easily pass
6. 0.035-inch guidewire—establish 'deep wire access' of CBD into duodenum
7. Wire basket retrieval device— inserted through the choledochoscope (over the wire)
8. 8 mm balloon dilator (40 cm)—cystic duct dilation
9. 6 mm and 8 mm balloon dilator (75 cm)—balloon sphincteroplasty of ampulla and sphincter
10. 12-French introducer sheath or 5 mm laparoscopic trocar—insertion of wires, balloons, choledochoscope without air leakage

CBD, common bile duct; EHL, electrohydraulic lithotripsy; LCBDE, laparoscopic common bile duct exploration.

5. Remove the balloon dilator and insert a choledochoscope over the guidewire into the cystic duct.
6. Start continuous normal saline irrigation through the choledochoscope using a pressured bag to distend the bile ducts and allow for optimal visualization.
7. Advance the choledochoscope into the CBD, identify CBD stones and any other luminal obstructions.
8. Clear the CBD of stones using the appropriate modality based on the size and location of the stone(s), size of the cystic duct, and available equipment.
   a. Most stones<8 mm can be grasped with a wire basket, passed through the choledochoscope, and pulled out by withdrawing the scope and basket/stone together out of the cystic duct.
   b. Alternatively, some stones can be pushed through the ampulla with the scope or captured in the wire basket and then pushed through the ampulla into the duodenum.
   c. Larger stones or impacted stones that cannot be captured or pushed into the duodenum can be treated with electrohydraulic lithotripsy (EHL) or laser lithotripsy, to break the stone into smaller fragments, and then extract as described below.
   d. Alternatively, in the setting of large stones that cannot be extracted via a transcystic approach, you can convert to a transcholedochal CBDE as described below.
   e. Finally, stone extraction using a Fogarty balloon catheter inserted under fluoroscopic guidance or inserted alongside the choledochoscope can be performed.
9. Once stones are cleared, perform a completion choledochoscopy to visualize the CBD, the ampulla, and advance into the duodenum. Also, attempt to visualize the proximal common hepatic duct and left/right hepatic ducts, if possible, to ensure no proximal stones are left behind.
10. Perform a balloon sphincteroplasty, if desired. For example, if the patient has a tight ampulla, slow or no contrast flow through the ampulla on completion cholangiography, or if attempting to push large stones through the ampulla (which can be performed earlier in this sequence to assist with stone clearance into the duodenum).
    a. Insert an 8 mm balloon over the wire and into the duodenum under fluoroscopic guidance.
    b. Inflate the balloon with contrast and then withdraw it until it stops at the ampulla. Mark this location on the fluoroscopy screen.
    c. Deflate the balloon and withdraw the deflated balloon to the center on the marked area of the ampulla/sphincter.
    d. Inflate the balloon to 8 mm—one will visualize a "waist" in the mid-portion of the balloon (figure 2), that is, the ampulla.[18] Continue inflation until this waist disappears. We inflate and hold for 2–3 minutes and then repeat for one additional cycle, although protocols/practices for this vary widely. Note that shorter balloon inflation durations have been associated with an increased risk of post-dilation pancreatitis.[19]
    e. Repeat the above with a larger balloon if needed, but the balloon diameter should not exceed the CBD diameter.
11. Perform completion cholangiogram.

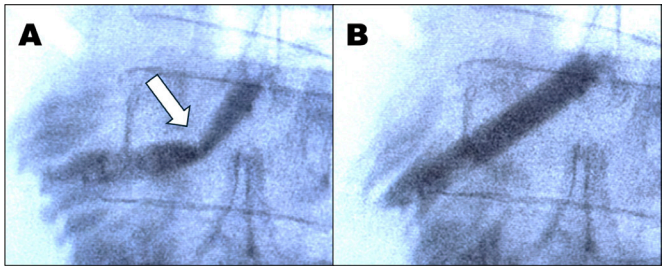

Figure 2 Balloon sphincteroplasty with an 8 mm balloon, (A) initial inflation with the white arrow showing the narrowed 'waist' indicating the sphincter and (B) complete balloon inflation.

Technique for electrohydraulic lithotripsy (if needed)

1. Ensure you are using saline irrigation through the scope and not sterile water.
2. Power on the EHL Autolith system and set the initial number of pulses and power settings.
   a. Start at one to two pulses and low power. Higher pulse number and power settings will decrease the longevity of the probe.
3. Position the choledochoscope with the stone in the center of the field. Pass the EHL probe through the scope and advance until the tip is in contact with the stone.
4. Withdraw the probe to 1–2 mm from the stone and activate the EHL using the foot pedal.
5. Assess the response and repeat lithotripsy until adequately fragmented for extraction.
   a. There is rarely a need to increase the pulse number greater than 5 or power greater than medium.
6. Remove the EHL probe and manage the resultant stone fragments as described above.

Technique for transcholedochal duct exploration (if needed)

1. This may be required for large stones that are not amenable to any of the above techniques, or patients with prior cholecystectomy, or patients with altered anatomy (Roux-en-Y gastric bypass), making ERCP not possible.
2. Ideally performed on a dilated CBD—at least 8–10 mm in diameter to allow for closure without a risk for stricture.

3. Expose the anterior surface of the CBD and the cystic duct junction.
4. Make a longitudinal anterior choledochotomy using a laparoscopic scalpel or hook cautery on cut mode.
   a. Often, stay sutures are not helpful.
5. Extend the choledochotomy to the desired length (usually about 1 cm) with scissors.
6. Flush duct via choledochotomy with suction/irrigator or red rubber catheter—this will often remove non-impacted stones.
7. Pass the guidewire into the CBD and duodenum (if able).
8. Insert the choledochoscope over the wire and directly into the CBD.
   a. This part of the procedure will typically be much easier than the transcystic approach
9. Perform any required interventions for remaining stones, for example, lithotripsy or balloon sphincteroplasty as described above.
   a. We often do balloon sphincteroplasty in this setting to reduce back pressure on the choledochotomy closure.
10. Close the choledochotomy with a running or interrupted absorbable suture. Typically, a running 3–0 or 4–0 Vicryl suture is used. In the setting of a dilated duct and resolution of the CBD obstruction, no T-tube is required. The T-tube is used in a non-dilated duct or if the CBD exploration was not successful in removing the source of obstruction.

LCBDE versus preoperative/postoperative ERCP

Numerous studies have demonstrated that LCBDE (transcystic or transcholedochal) is associated with a high success rate and low complication rate.[17 20–24] Additionally, most series highlight significant advantages in hospital length of stay and cost reduction when employing a single-stage approach—combining laparoscopic cholecystectomy with LCBDE—compared with a multistage approach that includes preoperative or postoperative ERCP in addition to cholecystectomy.[20 25–27] However, these studies primarily originate from high-volume centers with experienced hepatobiliary or minimally invasive surgeons. Success rates may be notably lower in other settings, particularly during the early phases of a surgeon's learning curve.

A network meta-analysis evaluating management strategies for CBD stones compared single-stage approaches (laparoscopic cholecystectomy with LCBDE or intraoperative ERCP) to multistage approaches (laparoscopic cholecystectomy with preoperative or postoperative ERCP).[25] Among the 16 studies encompassing over 8000 patients, findings indicate that single-stage management resulted in shorter hospital stays and lower complication rates, making it the optimal modality.[25 28] However, intraoperative ERCP requires careful coordination between the operating room, surgeon, and gastroenterologist, which limits its practicality in most centers across the USA. Consequently, the preferred approach in many institutions is laparoscopic cholecystectomy with intraoperative cholangiogram and common bile duct exploration as needed.

Considerations for LCBDE

Large meta-analyses have reported no significant differences in mortality and morbidity between endoscopic methods and laparoscopic bile duct clearance, with comparable failure rates between the two approaches.[24 25 29] However, the literature presents mixed findings, with some studies indicating higher rates of postoperative bile leakage and retained stones after LCBDE when compared with ERCP.[10 11 28–30] More literature is needed to delineate these outcomes.

Concerns about retained stones may lead surgeons to favor the choledochotomy approach. However, multiple studies highlight the advantages of the transcystic approach, including shorter operative times, reduced hospital stays, and lower rates of postoperative complications.[31 32]

A significant barrier to LCBDE adoption is its technical complexity, compounded by the limited exposure to LCBDE training during surgical education. Advancements in fluorescence-guided navigation, such as the use of indocyanine green (ICG) imaging, have shown promise in improving surgical technique. A randomized trial demonstrated that surgeons using ICG in LCBDE experienced shorter operative times, fewer complications, and decreased conversion rates to open surgery.[33] With continued advancements in technology and surgical training models, more surgeons may become proficient and comfortable with the LCBDE approach.

Additionally, institutional workflows can hinder LCBDE implementation. In some healthcare systems, surgeons are not consulted until after an ERCP has already been performed, limiting the opportunity to consider LCBDE as a primary intervention.[8] Increasing awareness among hospital administrators of the safety, cost-efficiency, and shorter hospital stays associated with LCBDE could encourage greater adoption of this technique.[8]

Although ERCP remains an effective approach, it is important to acknowledge the associated risks, including postprocedural pancreatitis, bleeding, perforation of the duodenum or bile duct, cholangitis, contrast allergies, technical difficulties, and long-term complications such as duodenobiliary reflux or ampullary stenosis due to sphincter of Oddi disruption.[28 29 34]

CONCLUSIONS

Although preoperative or postoperative ERCP has become increasingly popular, it exposes patients to an additional procedure with its own risks and potential complications. LCBDE offers a viable alternative, allowing for definitive management in a single stage and reducing the need for multiple interventions, ultimately leading to comparable outcomes and shorter hospital stays. Given that trauma and acute care surgeons frequently encounter choledocholithiasis, it is essential for them to be well-versed in its management, including the single-staged approach of LCBDE combined with laparoscopic cholecystectomy.

Acknowledgements Some of this work will be presented at the 2025 Trauma, Critical Care, and Acute Care Surgery Conference, Las Vegas, Nevada, USA.

Contributors Both authors (KC and MJM) contributed to planning, conducting, and reporting the work above. MJM is the guarantor of the article.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval Not applicable.

Provenance and peer review Commissioned; externally peer reviewed.

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