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EVIDENCE-BASED CURRENT SURGICAL PRACTICE

Endoscopic Management of Acute Biliopancreatic Disorders

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Abstract

Purpose Endoscopy is playing an ever-increasing role in the management of acute biliopancreatic disorders. With the management paradigm shifting away from more invasive surgical approaches, surgeons need to be aware of the treatment options available to improve patient care. Our manuscript serves to improve surgeons' knowledge and understanding of these emerging treatment modalities to expand their algorithmic approach to biliopancreatic disorders.

Methods Specific acute biliopancreatic disorders were identified from the literature and personal practice to create a structured review of common problems experienced by a surgeon of the gastrointestinal tract. An exhaustive literature review was performed to identify and analyze endoscopic treatment modalities for these disorders.

Results Endoscopic therapies continue to expand rapidly with a robust supportive literature. Data on endoscopic treatment strategies for acute biliopancreatic disorders demonstrate valuable improvements in outcomes in a number of these disorders.

Discussion Acute biliopancreatic disorders represent one of the most challenging pathophysiologies that a surgeon of the gastrointestinal tract may face. This manuscript represents a review of available endoscopic instrumentation as well as the author's interpretation of the current literature regarding indications and outcomes of endoscopic management for acute biliopancreatic disorders. Although this article does not supplant formal training in therapeutic endoscopy, surgeons reading this article should understand the role endoscopy plays in the management of acute biliopancreatic disorders.

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CME questions for this article available to SSAT members at http://ssat.com/jogscme/

Learning Objectives
1. Describe current endoscopic management options for acute biliopancreatic disorders
2. Discuss endoscopes and endoscopic accessories used in therapeutic endoscopy of the biliopancreatic system
3. Recognize the common complications of endoscopic biliopancreatic interventions

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Introduction

Acute processes of the biliopancreatic tree fall into three broad categories (obstructive, infectious, and traumatic), often occurring in combination with one another. In severe cases, all three can occur simultaneously; for example, a common bile duct (CBD) stone retained at the time of cholecystectomy leading to CBD obstruction, cholangitis, and eventual cystic duct stump leak. The role of endoscopy in the management of such acute biliopancreatic disorders continues to expand as both technologies and techniques have evolved over time. With the management paradigm for these disorders shifting away from invasive (and even minimally invasive) surgical approaches towards endolumenal and transluminal therapies, surgeons must be well-versed in the wide array of endoscopic management options available to improve the quality and efficiency of patient care.

This manuscript provides an overview and interpretation of the latest clinical data on common acute biliopancreatic disorders and describes the role that flexible endoscopy plays in the multidisciplinary management strategy. We outline the indications for and complication rates of these endoscopic interventions and also review novel/emerging endoscopic interventions that may supplant current surgical therapy. After reading this review, surgeons should understand how endoscopic treatment options complement surgical procedures within an algorithm that provides optimal outcome for their patients.

Overview of Available Endoscopic Tools

Endoscopes

Flexible endoscopy has evolved considerably over the past century to become the therapeutic mainstay that it is today. Modern endoscopy utilizes both forward-viewing and side-viewing endoscopes. Most surgeons have utilized a standard forward-viewing endoscopes for diagnostic procedures such as colonoscopy and upper endoscopy. Side-viewing endoscopes have more specialized functions and are less frequently utilized by surgeons. Because the optics are perpendicular to the endoscope tip, navigation and scope positioning are also challenging to master, requiring somewhat blinded maneuvering through the gastrointestinal (GI) tract. Despite the challenges, side-viewing endoscopes are optimized to access and intervene on the biliary tree and pancreatic ducts because of the location of the ampulla on the medial wall of the duodenum. A side-viewing duodenoscope is the most common endoscope used to access the biliary tree for endoscopic retrograde cholangiopancreatography (ERCP) and other interventions (Fig. 1). It has the same functions and controls as a standard endoscope with the addition of an elevator on the instrument channel which allows the endoscopist to direct the instruments independent of the endoscope tip to allow ampulla cannulation.

The echoendoscope is the second staple in the endoscopist's armamentarium for biliary endoscopy. Echoendoscopes have an ultrasound transducer at the tip of the endoscope that permits visualization of structures within

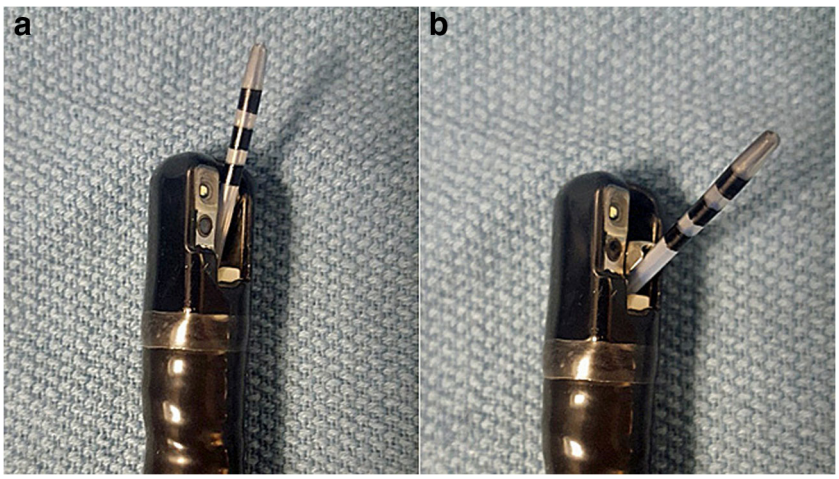

Fig. 1 Duodenoscope tip. **a** Side viewing camera/lens assembly and a catheter in the working channel. **b** The channel elevator can be used to direct instruments independent of the scope tip movements

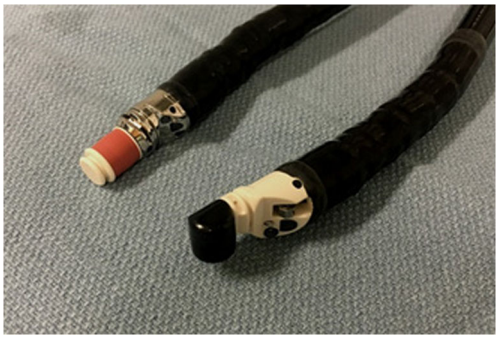

Fig. 2 Echoendoscope tips. Side viewing camera/lens assembly with distal-mounted radial/360° (left) and linear/180° (right) ultrasound transducers

or adjacent to the GI tract. Echoendoscopes also retain the same functions and controls of a standard duodenoscope and use an instrument elevator to direct instruments independent of the scope tip (Fig. 2). Because they are a side-viewing endoscope, echoendoscopes require additional navigation skills to avoid perforation when traversing the duodenal sweep. In acute pancreaticobiliary diseases, endoscopic ultrasound (EUS) is used to evaluate for common bile duct for stones, to identify fluid collections or a hollow viscus and to guide needle and/or wire access.

Instruments

A wide array of instruments are available for endoscopic biliopancreatic interventions. Grasping and biopsy forceps, wire baskets, and snares in a variety of shapes can be used for specimen extraction. Endoscopic brushes can be used to obtain cells for cytology if there is concern for malignancy. Endoscopic needles can be used to inject or aspirate fluid collections, or puncture a cavity to gain wire access for instrument exchange or stent placement. Incising tissue and coagulation can be performed with a needle-knife, triangle knife, or (most commonly) a sphincterotome which are also designed to permit both rapid cannulate the ampulla and radial cutting of the sphincter muscle. In patients on therapeutic anticoagulation or with a bleeding diathesis, sphincterotomy is not recommended due to the risk of post-sphincterotomy bleeding. In such cases, radially expanding balloon dilators can be used to dilate the sphincter to aid in stone extraction or duct decompression. Stone removal is completed with a stone extraction balloon which is deflated and inserted retrograde into the deep biliary system and then inflated to sweep stones antegrade. Alternatively, stones can be broken up with a mechanical lithotripter. Similar to an endoscopic basket, a lithotripter

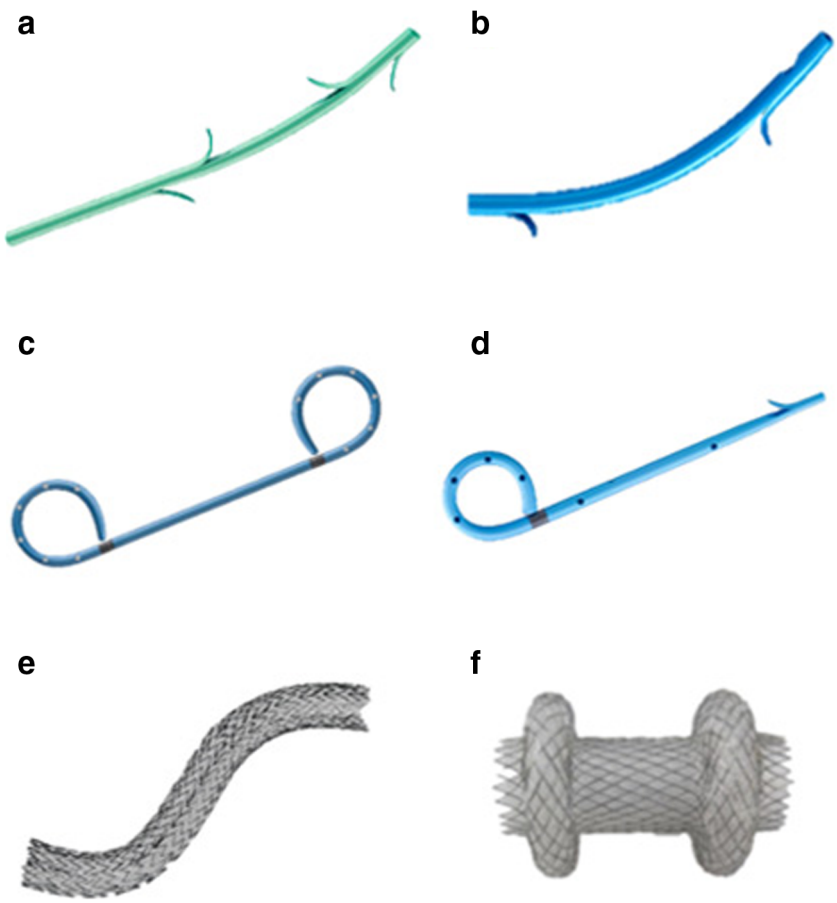

Fig. 3 Biliopancreatic stents. Geenen pancreatic stent (**a**), double flanged biliary stent (**b**), double (**c**) and single (**d**) pigtail stents, self-expanding metal biliary stent (**e**), lumen apposing stent (**f**)

Table 1 American Society of Gastrointestinal Endoscopy clinical predictors of CBD stones. The presence of any very strong predictor or both strong predictors is an indication for preoperative ERCP[5]

Very strong predictors	Strong predictors
CBD stone on ultrasound	Dilated CBD on ultrasound (> 6 mm)
Clinical ascending cholangitis	Bilirubin 1.8–4 mg/dL
Bilirubin >4 mg/dL	

is passed retrograde up the bile duct to the level of the impacted stone and deployed to encompass the stone. The cage is then closed around the stone to break it up. After stone extraction, stents are placed into the tract to maintain patency and promote drainage. Stents come in a variety of shapes including flanged, double pigtail, and expandable metal stents (Fig. 3). Recently, expandable luminal apposing stents have been used to bridge apposing cavities and promote drainage. These will be discussed further later in the review.

Choledocholithiasis and its Sequelae

Epidemiologic studies from the USA demonstrate that 5–26% of the population is living with cholelithiasis. Choledocholithiasis complicates 15–20% of those cases.[1] Common signs of uncomplicated disease consist of biochemical evidence of a conjugated hyperbilirubinemia, mild transaminitis, and alkaline phosphatemia. Symptoms include right upper quadrant pain, right shoulder pain, and potentially costovertebral angle tenderness. Ultrasound typically performed to evaluate for cholecystitis can often document evidence suggestive of choledocholithiasis including cholelithiaisis and intra- or extra-hepatic bile duct dilatation. Magnetic resonance cholangiopancreatography (MRCP) is the typically the confirmatory modality of choice for the diagnosis of choledocholithiasis and accurately identifies 90% of stones > 8 mm.[2] Endoscopic ultrasound has similar accuracy in diagnosing common bile duct stones but is more sensitive than MRCP at detecting stones < 5 mm.[3,4] Because of the risks associated with endoscopic biliary intervention, it is recommended that a diagnosis of choledocholithiasis be established via MRCP or EUS prior to proceeding with ERCP whenever possible.[3] The American Society of Gastrointestinal Endoscopy guidelines recommend preoperative ERCP based on clinical data including dilated CBD, elevated total bilirubin, and evidence of cholangitis or biliary pancreatitis. Strong and very strong predictors of CBD stones warranted preoperative ERCP based on their risk stratification model (Table 1).[5]

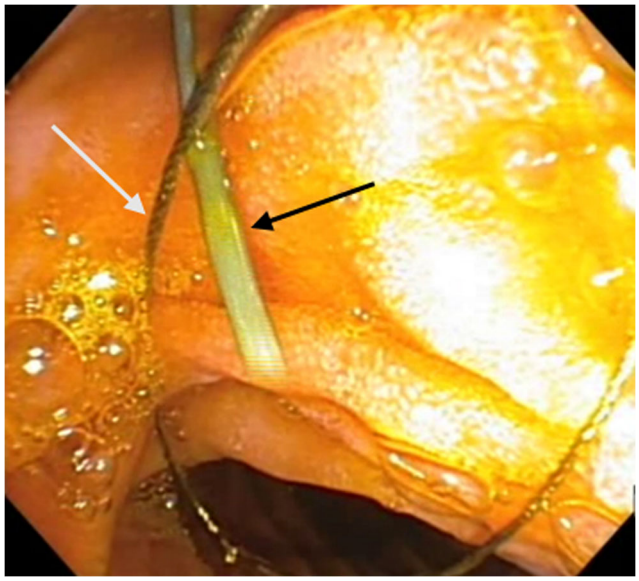

Fig. 4 Antegrade wire, rendezvous cannulation. A flexible tip guidewire (black arrow) is passed antegrade down the bile duct, through the ampulla and into the duodenum where it is captured with an endoscopic snare (white arrow) and pulled through the endoscope channel. This eliminates the need to cannulate the biliary orifice endoscopically

Despite the fact that the number of ERCPs performed annually have doubled in past decade, most surgeons are not trained in and therefore do not routinely perform ERCP.[5] Gastroenterological societies recommend that trainees perform 200 ERCP procedures before initial credentialing in the procedure due to studies evaluating the learning curve to achieve a > 80% deep cannulation rate.[6–9] However, a recent review of 2392 surgeon-performed ERCPs demonstrated a high procedural success rate and short-term complication rates consistent with published data and guidelines.[10] This highlights the need for an alternative credentialing pathway for surgical endoscopists who have received training in ERCP and can competently and safely perform the procedure despite their alternative (non-gastroenterology fellowship) training pathway.

The Incidentally Identified Choledocholithiasis

When identified preoperatively, the current treatment paradigm for choledocholithiasis is typically by upfront ERCP followed by cholecystectomy. When common duct stones are identified at the time of cholecystectomy, management is more challenging. In a review of 700 patients undergoing cholecystectomy in whom routine intraoperative cholangiogram was performed in all cases, 6% were incidentally found to have findings concerning for choledocholithiaisis.[11] While the incidence is low, surgeons must be versed in the management options. Historically, common bile duct exploration was the gold standard with open cholecystectomy but with the adoption of laparoscopic cholecystectomy,

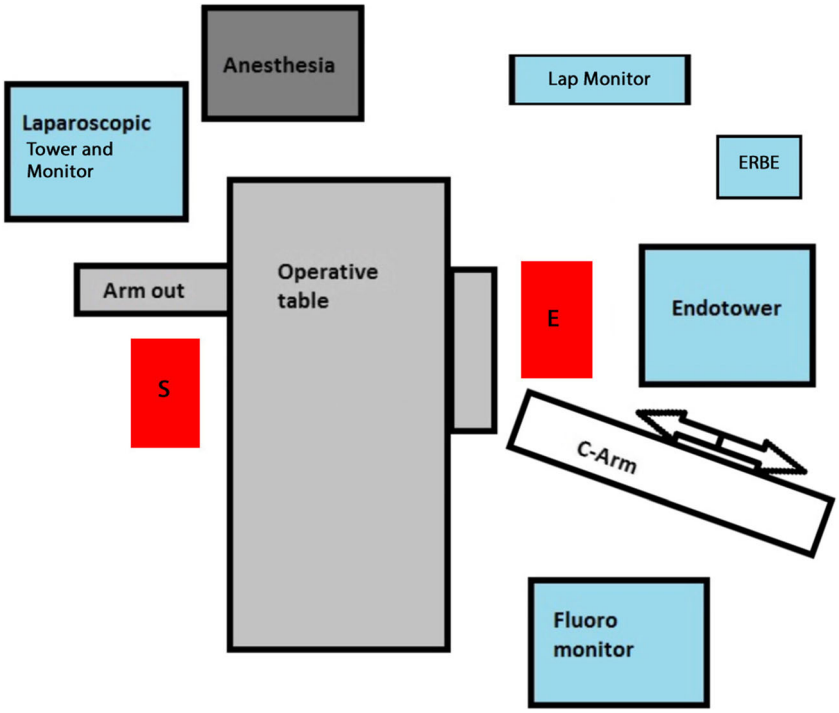

Fig. 5 Operating room setup for intra-operative ERCP. Patient is supine on the operating room table with right arm extended and left arm tucked. Surgeon (S) stands at patient right with the endoscopist (E) at the head of the bed or off the patient's left shoulder. Laparoscopic, endoscopic, and fluoroscopic equipment is positioned as indicated

common duct exploration became a much more challenging endeavor with many fewer surgeons attempting the procedure.[12]

Choledochoscopy represents a feasible option for single-stage management of incidentally found common duct stones with a success rate ranging from 87 to 95% and complication rates ranging from 4 to 8%.[14,15] Choledochoscopy requires passing a slim endoscope through the cystic or common duct and directly removing the stones. The number of surgeons comfortable with this procedure however is small with many preferring to refer the patient for postoperative cholangiography via ERCP or transhepatic methods. Single-session, intraoperative ERCP is an option but scheduling is challenging and may require the mobilization of a surgical and an endoscopy team. In addition, supine patient positioning makes biliary cannulation more challenging for the endoscopist. When successfully arranged, single-session intraoperative ERCP has demonstrated success and complication rates similar to traditional preoperative ERCP albeit with an increased overall operative time.[16] This issue is offset by a shorter total hospital length of stay and a higher patient desire for single stage (vs multistage) procedure.

In an attempt to facilitate ERCP in the supine position and improve success rates, methods of antegrade-wire rendezvous cannulation of the biliary tree has been described that facilitates on-table ERCP at the time of laparoscopic cholecystectomy by passing a wire antegrade through the cystic duct into the duodenum to assist with retrograde cannulation of the biliary tree (Fig. 4). This technique shows promise in decreasing the incidence of post-ERCP pancreatitis and improving success rates by permitting immediate and definitive access to the bile duct alone **(**Fig. 5**).**[17,18]

Acute Biliary Pancreatitis

Choledocholithiasis can cause a partial or complete obstruction of the biliary tree, resulting in obstructive jaundice and potentially biliary pancreatitis. Biliary pancreatitis is associated with significant morbidity and early definitive therapy both reduces the severity of disease and the incidence of recurrence.[3] Treatment of acute biliary pancreatitis is ERCP followed by cholecystectomy, preferably during the same hospitalization. Urgent ERCP (within 24 h of diagnosis) is indicated in cases of biliary pancreatitis with associated cholangitis.[19] In the setting of common bile duct stones and cholestatic jaundice, preoperative ERCP is still recommended before performing cholecystectomy.[20]

Recent studies have evaluated the safety and effectiveness of performing single-session ERCP and cholecystectomy.[21–23] While recognizing the challenge of scheduling, single-session ERCP-cholecystectomy led to shorter hospital stays and reduced total cost. To help facilitate single-session ERCP, an antegrade rendezvous method of biliary cannulation for single-session ERCP/cholecystectomy is described. The technique utilizes standard intraoperative cholangiogram steps to access the cystic duct and pass a wire down the biliary tree into the duodenum prior to removing the gallbladder.[18] The wire is then easier to grasp with a side viewing endoscope for direct retrograde cannulation of the deep biliary tree for interventions. This technique may increase

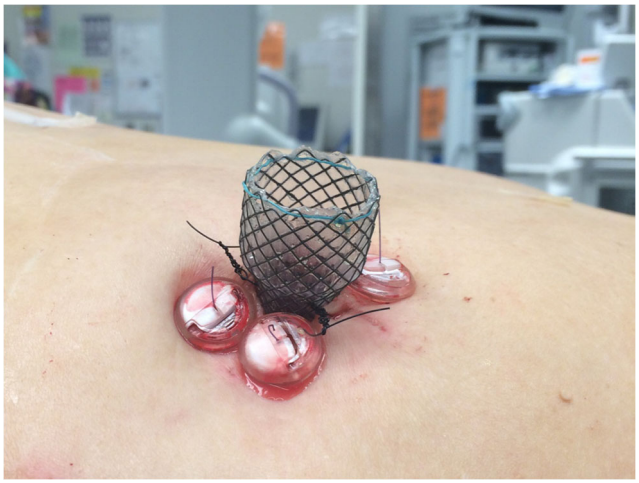

Fig. 6 Transabdominal access to the gastric remnant secured with gastrointestinal t-anchors and a covered stent to allow passage of a duodenoscope for ERCP

the rate of biliary cannulation and decreases the incidence of pancreatic duct cannulation theoretically decreasing the rate of post-ERCP pancreatitis.[24]

Choledocholithiasis in Patients with Altered Foregut Anatomy

When patients have had alterations to their foregut anatomy from prior surgery, accessing the biliopancreatic tree for intervention becomes much more challenging. Options for accessing the excluded biliary system include balloon-assisted enteroscopy (BAE) with ERCP and laparoscopic-assisted transgastric (LAT-) ERCP via the gastric remnant.

Balloon-assisted enteroscopy was first described by Yamamoto et al. in 2001 as a method of providing deep endoscopic access to the entire small bowel.[2] Balloon-assisted enteroscopy has since been adapted and utilized in post-bariatric surgical patients to provide retrograde endoscopic access to the bypassed foregut structures for diagnostic and therapeutic uses.[25–28] In BAE, a balloon overtube is advanced over the endoscope and inflated to contact the bowel wall. The friction between the balloon and the bowel wall is used to pull the endoscope forward a short distance and the steps repeated. This push-and-pull technique can be used to telescope the bowel over the endoscope as it advances. The BAE endoscopy is continued retrograde until the ampulla is reached.

In LAT-ERCP, a laparoscopic port is placed into the gastric remnant to facilitate passing a side-viewing duodenoscope for antegrade ERCP. ERCP is then performed in standard fashion through the gastric remnant. In a comparative analysis at a single center, LAT-ERCP had a greater clinical success rate compared with BAE (100% v. 59%), shorter procedure times, and similar complication rates.[29] Other reports corroborate these findings but do report a higher complication rate related specifically to the gastrostomy tube.[30] A recent multicenter study of 509 patients who underwent LAT-ERCP demonstrated success rates equivalent to ERCP in native gastric anatomy (98%) with similar ERCP-related complication rates. Overall, complication rates were slightly higher related to the laparoscopic portion of the procedure.[31] At the completion of the procedure, a gastrostomy tube can be placed to facilitate biliary stent removal at a later date and to provide emergent access if the patient develops complications of ERCP such as post-sphincterotomy bleeding or cholangitis. If no stent is left, the gastrotomy can be sutured or stapled close at the completion of the case. The gastrostomy tube is typically removed at the time the biliary stent is removed and the patient no longer has an indication for biliary access. Removing the gastrostomy tube can be performed at the bedside, and in most cases, the tract will close spontaneously but in some cases may require operative intervention to close the gastrotomy.

Smaller case reports exist in the literature describing transabdominal ultrasound-guided access into the gastric remnant.[31] The tract is secured with T-anchors and/or stents (Fig. 6) and serially dilated up to allow passage of a standard duodenoscope for ERCP. At the completion of the procedure, a gastrostomy tube is placed in the tract to maintain patency.

Infections of the Biliopancreatic Tree

Cholangitis

Cholangitis is the result of biliary stasis and bacterial overgrowth within the bile ducts and commonly occurs secondary to stones, strictures, or stents. It can also occur after direct

Fig. 7 CT imaging demonstrating an infected pancreatic WON (star) within the pancreatic body (small arrow). The stomach lies just anterior to the collection (large arrow)

instrumentation of the biliary tree. Patients present in sepsis with biochemical evidence of obstructive jaundice. Initial treatment is supportive with early initiation of antibiotics, fluid resuscitation, and hemodynamic support. In addition to supportive measures, biliary drainage is required for successful treatment.[32] Endoscopic biliary drainage has largely supplanted surgical drainage for the treatment of acute cholangitis since first being described in 1973.[33] This is achieved via ERCP with clearance of the duct and sphincterotomy prior to placement of a new endobiliary prosthesis to permit drainage.[32] Success rates have been reported as high as 98% of cases.[34] Patients in whom endoscopic drainage of the biliary system is unsuccessful should undergo percutaneous transhepatic biliary drainage. In patients who are at a high risk for bleeding, endoscopic nasobiliary tube drainage can be performed and allows for biliary lavage and decompression. Optimal timing for ERCP is within 48 h of presentation to the hospital. Delays longer than 48–72 h are associated with increased hospital length of stay and adverse outcomes including hypotension requiring vasopressor support.[35,36]

Infected Pancreatic Walled-off Necrosis, Infected Pseudocysts

Necrotizing pancreatic infections carry a high morbidity and mortality and were historically treated with open pancreatic necrosectomy. Despite radical surgical debridement, outcomes were still poor. Because of this, the treatment paradigm has shifted from a maximally invasive strategy to a "step-up" minimally invasive approach to the management of pancreatic necrosis.[37] Recent studies have examined a delay—drain—debride strategy rather than upfront aggressive surgical intervention. Initial treatment is focused on medical management; supportive care allows for recovery from the initial pancreatitis and time for the pancreatic necrosum to form a walled-off collection that can be treated as an abscess cavity. The infected walled-off necrosis (WON) is then drained either percutaneously or endoscopically via a transmural approach (Fig. 7). Comparisons between open debridement and minimally invasive video-assisted debridement found that the minimally invasive approach had a much lower rate of multi-system organ failure without significant difference in mortality.[36,38]

Continuing the "step-up" approach, the multicenter Dutch trial randomly assigned patients to either endoscopic or percutaneous drainage for pancreatic necrosis. Major complications and death were similar between the two groups while the endoscopic group had shorter length of stay and fewer pancreatic fistulas as a complication of their procedures.[37] Based on this data, the American Society for Gastrointestinal Endoscopy recently published their guidelines for endoscopic management of WON.[39] Guidelines state that optimal drainage is obtained transmurally with endoscopic ultrasound guidance, multiple stents for decompression, and, when indicated, endoscopic necrosectomy.

Luminal apposing stents have been utilized to improve drainage and access to the WON cavity for direct endoscopic debridement after initial drainage.[13,40,41] Multiple debridements over several days are typically required to adequately debride and treat the necrosum. Endoscopic management of pancreatic collections is successful at avoiding surgical debridement and achieving clinical success in 70–80% of cases in multiple studies with mortality rates reported as 6% in a systematic review of 14 studies.[42–45] On average, patients require four endoscopic interventions for clinical resolution. Mechanical debridement and lavage are standard methods of necrosectomy with small studies reporting success with hydrogen peroxide irrigation of the cavity.[46–48] Sinus tract endoscopic debridement through a percutaneously drain has also been described in the literature with good clinical success.[48–50]

Trauma to the Biliopancratic System

Biliary Trauma

Injuries to the biliary system occur during surgery or trauma and result in bile leaks, bilomas, and cholangitis. Percutaneous drainage and endoscopic interventions to decompress the biliary system are recommended as initial treatment, but in some cases, hepatic resection is necessary to prevent ongoing leak.[50] Endoscopic management includes sphincterotomy, balloon dilation of strictures, and stenting to promote antegrade flow of bile. In situations where complex biliary fistulas persist, covered expandable metal stents can be used to bridge the defect and allow healing. Successful non-operative management of biliary trauma ranges from 70 to 96% when leak and stricture are present in isolation; however, when both stricture and leak are present, the rate of successful non-operative management drops to 30% and upfront surgical intervention is recommended.[51]

Post-Cholecystectomy Bile Leak

Clinically, significant post-cholecystectomy bile leaks complicate approximately 1% of all laparoscopic cholecystectomies.[1, 52] The most common source is from subvesicle ducts (Ducts of Luschka) or the cystic duct stump (Fig. 8). Diagnosis is made with focused ultrasound, 99mTc-hepatic iminodiacetic acid (HIDA scan), ERCP, or a combination of these studies. HIDA scan is 83–87% sensitive at detecting leak whereas ERCP is 95% sensitive. ERCP has the benefit of providing therapy if leak is diagnosed but carries procedural risks even in the event of a negative study.[53–55]

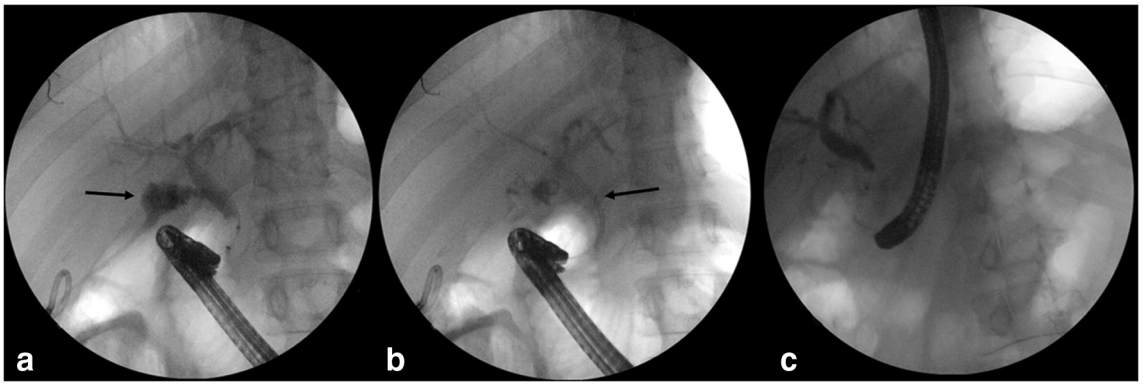

Fig. 8 Representative cholangiogram images demonstrating **a** contrast leak (arrow) from a cystic duct stump, **b** endoscopic biliary stent placement (arrow), and **c** stent removal at 4 weeks demonstrated resolution of the leak

Initial management of the leak should be focused on control of the intra-abdominal biloma (generally via percutaneous drainage) and transition to endoscopic interventions only in the event of persistent or high-grade leaks. Bile leaks persist because of backpressure created by an intact sphincter mechanism or by missed common duct stones. ERCP is necessary to eliminate that pressure gradient via duct clearance, transpapillary stenting, and/or sphincterotomy. In the case of retained common duct stones, sphincterotomy is usually required for stone extraction but in the absence of stones, it is generally advised to maintain the sphincter integrity when possible and simply bypass the sphincter with via stenting. Plastic transpapillary stents are left in place for 4–6 weeks or until extraluminal drainage has stopped, indicating the leak has closed. Patients whose leaks persist despite drainage with a well-positioned plastic transpapillary stent can have their stent exchanged for a covered expandable metal stent with good results.[55] Endoscopic management of post-cholecystectomy bile leaks approaches 100% success rates.[51]

Pancreatic Trauma

Isolated traumatic pancreatic injuries are rare (representing less than 1% of traumatic injuries), but carry significant morbidity and mortality.[56] They are more commonly part of a multivisceral injury pattern with a high injury severity score. Injuries to the pancreas can result in pancreatitis, pseudocyst formation, pancreatic necrosis, and duct disruption. When pancreatic injuries do occur, diagnosis can be difficult as biochemical markers and physical exam are unreliable in trauma patients. CT imaging is the initial diagnostic modality of choice despite widely variable sensitivity for detecting injuries.[57] Lack of parenchymal enhancement, peripancreatic fluid, and local fat stranding are suggestive of injury.

Although sometimes used, the role of endoscopy in the management of acute traumatic pancreatic injuries is still debated in the literature. Recent consensus guidelines from the Eastern Association for the Surgery of Trauma (EAST) recommend against the use of endoscopy in the management of traumatic pancreatic injuries, instead reserving endoscopy for diagnostic purposes and for the management of complications of the initial injury.

Pancreatic injuries are classified by grade. Grade I/II include parenchymal injury of varying degree without evidence of ductal disruption. Grade III/IV/V injuries include evidence of main duct disruption (Fig. 9).[58] Grade I/II injuries can be managed non-operatively whereas grade III+ injuries require operative intervention for pancreatic debridement/resection and drainage. ERCP offers diagnostic value when evaluating patients with a grade I/II injury on radiographic imaging where there is a high clinical suspicion for ductal disruption. If ductal disruption is diagnosed, the injury grade increases, and operative intervention is indicated to avoid complications of a missed ductal injury. Previously, when ductal injuries

Fig. 9 Imaging findings in blunt pancreatic trauma. **a** CT imaging demonstrates parenchymal disruption (arrow). **b** MRCP demonstrating complete disruption of the main pancreatic duct[58]

were identified, endoscopy played a key role in initial management. Current EAST guidelines recommended against endoscopic/non-operative management of pancreatic injuries complicated by ductal disruption. In their review of the literature, ERCP and stenting for Grade III+ injuries had greater treatment failures and higher morbidity than patients who underwent initial operative intervention. However, endoscopy does offer benefit in the management of complications from pancreatic injuries. Patients who develop persistent pancreatic leaks after initial operative management may benefit from ERCP with pancreatic sphincterotomy and stenting to improve antegrade drainage and decrease fistula output.[59] Additionally, reports have demonstrated success with cyanoacrylate-injected closure of distal leaks when used in combination with antegrade drainage.[60] Patients who develop pancreatic pseudocysts benefit from endoscopic cystgastrostomy/cystjejunostomy for adequate drainage.

Endoscopic Management of Cholecystitis

Cholecystectomy is the gold standard treatment for the definitive management of cholecystitis. In certain clinical scenarios, patients may not be able to tolerate cholecystectomy due to operative risk associated with general anesthesia or the surgical procedure. Patients who are poor operative candidates for operative intervention are typically managed with percutaneous cholecystostomy tube placement for external biliary drainage. While effective, percutaneous cholecystostomy tubes are uncomfortable and at risk of dislodgment, and recent studies have questioned whether they represent any overall benefit.[61–63] Moreover, after the tube is removed, patients are at similar risk for recurrent episodes leading some providers to use percutaneous drainage as destination therapy.

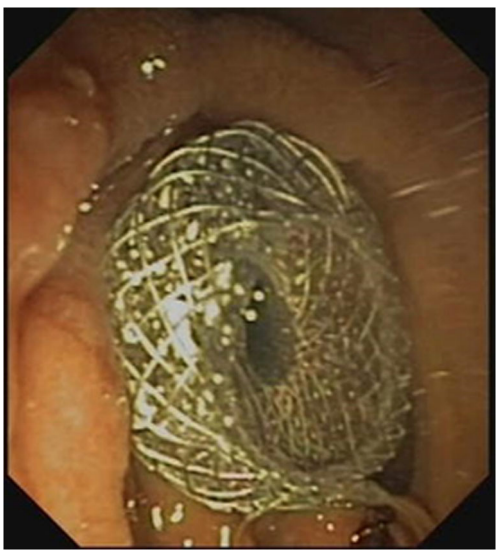

Fig. 10 Lumen-apposing stent used for choledochoduodenostomy[68]

Endoscopic options for external biliary drainage included nasobiliary drainage catheters. Like percutaneous cholecystostomy catheters, nasobiliary drainage catheters are at risk of dislodgement and are poorly tolerated by patients. Therapy is also temporary as when the tube is removed, patients have similar risk for recurrent episodes.

Endoscopic or percutaneously placed cystic duct stenting for acute cholecystitis has been trialed in patients who are not candidates for cholecystectomy.[64–66] Indications for cystic duct stenting in the setting of acute cholecystitis included poor/nonsurgical candidate, cirrhosis, and unresectable cancer. Initial success rates were > 75% with good reported long-term success and average stent patency 760 days and low recurrence rates.[65] The highest rates of recurrence were in unresectable cancer patients (averaging 10.5% at 1 year).[67] Cystic duct stenting was utilized as destination therapy in these select cases and therefore routine long-term management was not performed. Patients were considered definitively treated unless they had recurrent episodes of cholecystitis or complications of the procedure.

Recently, EUS-guided internal drainage of the gallbladder has gained favor for the treatment of cholecystitis in cases where patients are not candidates for definitive cholecystectomy. EUS-guided drainage utilizes a linear side viewing echoendoscope advanced into the distal antrum or proximal duodenum. The gallbladder is identified where it lies directly in apposition to the intestinal lumen and is punctured through the intestinal wall under ultrasound guidance. After confirming position, a guidewire is placed across and a fully covered lumen-apposing stent (AXIOS Stent; Boston Scientific, Marlborough, MA) is placed across the tract (Fig. 10).[68–70] The literature is presently limited to case reports and case series with short-term outcomes up to 1 year.[70–72] Despite the relatively early data, EUS-guided drainage with a lumen-opposing stent was clinically successful for the treatment of cholecystitis in nearly 100% of cases attempted with no significant adverse events reported.[69,73] Stent removal was performed at variable times after initial placement, and the stent was left permanently in some patients due to patient clinical condition or patient refusal. There were no reports of recurrent episodes of cholecystitis. Longer term follow-up is needed to determine whether the cholecystoenteric fistula persists after stent removal in order to determine the optimal patient population to offer this therapy.

Complications of ERCP and EUS-Based Interventions

Complications of endoscopic interventions are rare but can be significant, particularly after ERCP. Post-ERCP pancreatitis

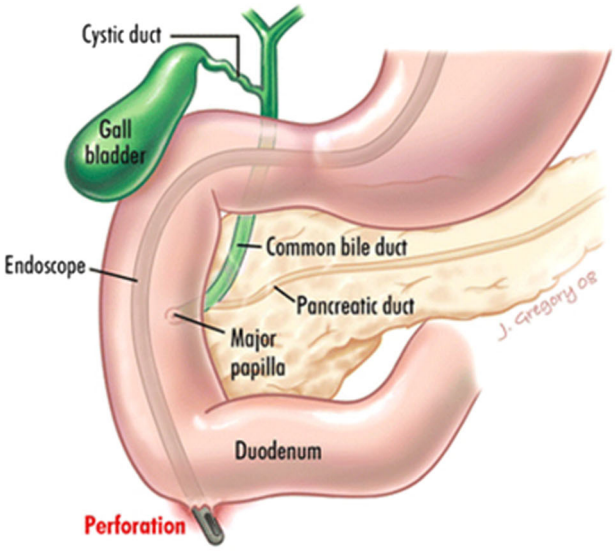

Fig. 11 Classification system for iatrogenic perforation during ERCP[78, 79]

Type	Definition	Rx
1	Lateral duodenal wall	Surgery
2	Peri-Vaterian	Surgery if large free air
3	Ductal	Same as 2
4	Retroperitineal air alone	Conservative

(PEP) is the most common complication following ERCP with an incidence of 3.7%.[74] The severity of the pancreatitis can vary. Mild cases of PEP result in biochemical evidence of pancreatitis and increased hospital length of stay. Severe cases of PEP can result hemorrhagic or necrotizing pancreatitis. Risk factors for PEP include female gender, previous episodes of PEP, history of pancreatitis, and sphincterotomy.[75] Difficult cannulation, inadvertent cannulation and contrast injection of the pancreatic duct, and failed duct clearance have also been shown to increase the risk of PEP. Preventive measures have been widely studied with unfortunately inconsistent results. Periprocedural hydration, NSAIDS, and rectal indomethacin demonstrate the most consistent reduction in PEP and are generally recommended. Prophylactic pancreatic duct stenting has shown promising results in some studies but is not widely accepted as standard of care.[76]

Bleeding

Bleeding occurs in 2% of procedures, most commonly related to sphincterotomy. While typically occurring early post ERCP, it has also been reported up to 2 weeks later. Mortality associated with post-ERCP bleeding is around 3.5%. Severity ranges from mild cases that do not require transfusion, mild cases that require transfusion but no intervention, and severe cases that require intervention. Prevention includes proper patient preparation including holding oral anticoagulants and reversal of coagulopathy in urgent settings. Technical considerations include performing sphincterotomy in the 11–1 o'clock position above the major papilla, creating a single tract, and the level of experience of the endoscopist.[77] Treatment includes endoscopic injection of dilute epinephrine injection, coaptive coagulation, endoclips placement, as well as reversal of anticoagulation and transfusion. When the risk for post-ERCP bleeding is high, such as anticoagulation that needs to be immediately restarted, balloon dilation rather than sphincterotomy should be strongly considered.[78]

Perforation

Perforation during ERCP occurs in < 1% of procedures but carries a high morbidity and mortality. Perforations are classified based on location and type in order to determine treatment (Fig. 11).[78–80] Type I injuries occur along the lateral or medial wall secondary to endoscope-related trauma. These injuries are often large and require immediate surgery to repair the duodenal wall and place drains. Type II injuries occur at or near the ampulla secondary to cannulation attempts and sphincterotomy. Type III injuries involve the proximal bile ducts and are caused by perforation during instrumentation of the deep biliary system.

Type II and III injuries vary in severity, and treatment is determined by clinical condition of the patient with some closing spontaneously without intervention. Treatment consists of percutaneous drainage, biliary stenting, and antibiotics. Type IV injuries include retroperitoneal air without evidence of contrast leak. These injuries are the result of excess insufflation during endoscopy leading to translocation of gas. These are not true perforations and typically do not require procedural intervention and can be conservatively manated.[81, 82]

Infectious Complications

ERCP is used to treat cholangitis but can also cause infections of the biliary tree through instrumentation and the use of biliary prosthesis. The overall incidence of post-ERCP infection is 1.4% of cases but carries a high mortality. Risk factors for post-ERCP infection include combined percutaneous and endoscopic procedures, incomplete duct clearance, indwelling prosthesis, and inexperience. Treatment and prevention consists of early pre and periprocedural antibiotics with gram-negative organism coverage. Taking steps to insure complete drainage reduces the rate of infection. That includes leaving a stent when there is incomplete drainage and obtaining percutaneous biliary drainage when endoscopic measures are unsuccessful.

Iatrogenic duodenoscope-associated infections are a relatively newly identified entity, spurred by the identification of clusters of infections occurring because of inadequate endoscope processing. This leads to retained biohazardous material on the scope, within the channels, and particularly in the elevator mechanism. Adequate endoscope processing techniques require initiation of the manual cleaning sequence immediately after removal from the body to prevent bodily fluids from drying and biofilms from forming. Single-use scope brushes should be used to clear the channels and around the elevator. The duodenoscope should be fully leak tested and the distal tip visually inspected for defects prior to automated cleaning sequences. Manufacturer specific cleaning sequences may also be required to ensure proper cleaning. Regular screening and microbiological surveillance of the duodenoscopes every 3 months is required to maintain compliance with regulations.[83]

Author Contribution Each author has participated sufficiently in this work to take public responsibility for appropriate portions of the content.

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CME/MOC Questions – 8 multiple choice (A-D) Outcomes of single session versus multi-session ERCP and cholecystectomy for the treatment of choledocholithiasis/biliary pancreatitis demonstrate that single session treatment has:

Similar length of stay and decreased cost
Decreased length of stay and similar cost
Decreased length of stay and decreased cost
Increased length of stay but decreased cost

Balloon-assisted endoscopy to facilitate ERCP in post-RYGB patients with choledocholithiasis has a biliary cannulation rate of:

> 90%
20-30%
50-60%
< 10%

Endoscopic options for management of acute cholecystitis in patients who are deemed poor surgical candidates include:

Percutaneous transhepatic cholecystostomy tube
Endoscopic creation of a cholecystoenteric fistula
Endoscopic sphincterotomy
No available endoscopic options

Postoperative bile leak complicates 1% of all cholecystectomies. The most sensitive study for detecting leak is

ERCP
Focused ultrasonography
HIDA
Computed tomography (CT) scan

The role of ERCP in pancreatic trauma includes:

ERCP is the gold standard diagnostic test for traumatic pancreatic ductal injuries
ERCP is useful in the diagnosis of occult pancreatic main duct injuries
ERCP with sphincterotomy is recommended in all cases of suspected pancreatic trauma
There is no role for ERCP in pancreatic trauma

The most common complication of ERCP with sphincterotomy is

Sepsis
Perforation
Bleeding
Pancreatitis

Adjuncts for reducing the incidence of post-ERCP pancreatitis include:

Rectal NSAIDs
Rectal Steroids
IV acetaminophen
Oral NSAIDs

Which of the following statements about single session ERCP and cholecystectomy is true?

The antegrade wire rendezvous technique via a cystic ductotomy can help facilitate cannulation of the biliary system
On table fluoroscopy is not necessary
Single session ERCP and cholecystectomy should not be performed due to increased adverse events
Patient position is not a challenge to single session ERCP and cholecystectomy