Gut and Liver
https://doi.org/10.5009/gnl250430
pISSN 1976-2283 eISSN 2005-1212

Review Article

Prevention and Management of Endoscopic Retrograde Cholangiopancreatography-Related Perforation: A Guideline-Based Narrative Review

Eaum Seok Lee[1,2], Jonghyun Lee[2,3]

[1]Department of Internal Medicine, Chungnam National University School of Medicine, Daejeon, Korea; [2]Policy-Quality Management Committee, Korean Pancreatobiliary Association, Seoul, Korea; [3]Department of Internal Medicine, Pusan National University School of Medicine, Biomedical Research Institute, Pusan National University Hospital, Busan, Korea

Article Info

Received September 1, 2025
Revised December 18, 2025
Accepted December 24, 2025
Published online March 15, 2026

Corresponding Author

Jonghyun Lee
ORCID https://orcid.org/0000-0002-9752-5860
E-mail keiasikr@pusan.ac.kr

Endoscopic retrograde cholangiopancreatography (ERCP) is important for the therapeutic management of pancreatobiliary diseases, but it carries a risk of perforation, an infrequent yet life-threatening adverse event. We summarize contemporary evidence on the prevention and management of ERCP-related perforation, aligning with current society guidelines (European Society of Gastrointestinal Endoscopy 2020, American Society for Gastrointestinal Endoscopy 2017, and Japan Gastroenterological Endoscopy Society 2018). We conducted a comprehensive narrative review by searching the PubMed, EMBASE, and Cochrane Library databases for articles published between January 2010 and October 2025. We prioritized current society guidelines, recent systematic reviews and meta-analyses, and landmark original studies, focusing on incidence, classification, risk factors, prevention strategies, and outcomes. Evidence was narratively synthesized to provide guideline-aligned recommendations. Perforation occurs in approximately 0.1% to 1.8% of ERCPs and is associated with substantial morbidity and mortality. The Stapfer system can be used to stratify injury severity and guide management. Most periampullary (Stapfer type II) and ductal (type III) injuries can be managed nonoperatively with endoscopic closure and/or diversion (e.g., fully covered self-expandable metal stents), whereas large, free-wall duodenal perforations (type I) often require early surgery. Early recognition, the use of CO_2 insufflation, careful sphincterotomy and dilation, and multidisciplinary care are associated with improved outcomes. Prevention through meticulous technique and appropriate case selection is important. When a perforation does occur, prompt classification and a stratified intervention approach (conservative, endoscopic, or surgical) can optimize treatment outcomes. Advances in endoscopic closure and diversion have significantly reduced the need for surgical intervention in many patients. However, prompt surgical management remains critical in select cases. **(Gut Liver, 2026;20:213-224)**

Key Words: Endoscopic retrograde cholangiopancreatography; Classification; Incidence; Risk factors; Treatment outcome

INTRODUCTION

Endoscopic retrograde cholangiopancreatography (ERCP) and related therapeutic procedures are essential for the diagnosis and treatment of biliary and pancreatic diseases. However, the incidence of complications from ERCP is higher than that of other endoscopic procedures, and serious adverse events can occur. Major complications of ERCP include pancreatitis, bleeding, perforation, and cholangitis. Acute pancreatitis has been reported in 0.5% to 6.9% of cases, bleeding in 0% to 27%, perforation in 0.1% to 1.8%, and cholangitis in 0% to 4.2% of cases.[1]

ERCP-related perforations can lead to life-threatening peritonitis, sepsis, and multi-organ failure if not promptly recognized and managed. Historically, a perforation during ERCP often necessitated emergent surgery, contributing to a reported mortality rate of up to approximately 10% in pooled analyses.[2] Therefore, it is crucial to become profi-

© Gut and Liver.
This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (http://creativecommons.org/licenses/by-nc/4.0) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

cient in techniques to prevent ERCP-related complications and to respond appropriately when they occur. This review provides a comprehensive overview of ERCP-related perforations, including classification, risk factors, prevention strategies, and evidence-based management approaches. We incorporate current expert consensus from major society guidelines (European Society of Gastrointestinal Endoscopy [ESGE] 2020, American Society for Gastrointestinal Endoscopy [ASGE] 2017, Japan Gastroenterological Endoscopy Society [JGES] 2018), and recent studies to guide optimal prevention and treatment of this complication.

METHODS

We conducted a comprehensive narrative review of ERCP-related perforations by searching PubMed, EMBASE, and the Cochrane Library for articles published between January 2010 and October 2025. Search terms included: "ERCP," "endoscopic retrograde cholangiopancreatography," "perforation," "duodenal perforation," "complication," "management," and "prevention." We prioritized current society guidelines (ESGE 2020, ASGE 2017, and JGES 2018), recent systematic reviews and meta-analyses, and landmark original studies. Articles were selected based on clinical relevance, methodological quality, and contribution to understanding classification, risk factors, prevention strategies, and management outcomes. Data were narratively synthesized to provide evidence-based recommendations aligned with current expert consensus. This review was designed as a guideline-based narrative review rather than a systematic review; therefore, a PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram was not generated.

1. Classification of ERCP-related perforation

The classification of ERCP-related perforations is based on the mechanism of occurrence and anatomical location. The system proposed by Stapfer *et al.*[3] is the most commonly used. It divides perforations into four types (Table 1, Fig. 1).[4]

- Type I: A perforation of the free wall of the duodenum, often caused by the endoscope tip during initial insertion. This tends to occur in patients with altered anatomy (e.g., Billroth II gastrectomy) where maneuvering the duodenoscope is challenging. For instance, forceful or excessively deep insertion of the duodenoscope can result in a tear of the duodenal wall.
- Type II: A periampullary perforation, occurring in the region around the papilla. Type II is the most common subtype, accounting for approximately 50% to 60% of all ERCP-related perforations.[5] It typically occurs during endoscopic sphincterotomy or during attempts to dilate the bile duct with a balloon.
- Type III: A distal bile duct or pancreatic duct perforation, usually caused by endoscopic instruments such as guidewires or dilators. Perforations from a guidewire tend to be small and often clinically insignificant. If a larger ductal perforation occurs due to a device (e.g., dilating instrument), placing a stent across the injury to prevent leakage can promote healing in most cases.

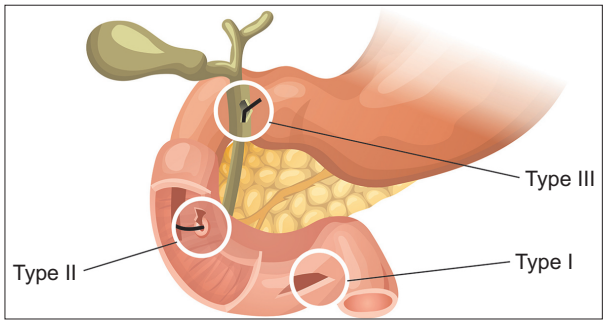


Fig. 1. Stapfer classification of endoscopic retrograde cholangiopancreatography-related perforations. Type I, perforation of the duodenum; Type II, periampullary perforation; Type III, bile duct perforation. Reproduced from Boonstra K, *et al.* Best Pract Res Clin Gastroenterol 2024;70:101890.[4]

Table 1. Stapfer Classification and Recommended Management Strategies

Stapfer type	Location	Mechanism	Frequency	First-line management	Surgical indication	Reference
I	Free wall duodenal perforation	Endoscope trauma (during insertion)	15%–20%	Endoscopic closure (TTSC/OTSC) (small defect, <13 mm)	Large defect (>2 cm), failed closure, delayed diagnosis	3,4,6
II	Periampullary region	Sphincterotomy, balloon dilatation	50%–60%	FCSEMS placement, biliary stenting	Diffuse retroperitoneal abscess, peritonitis, sepsis despite stenting	5,7,8
III	Bile, pancreatic duct	Guidewire, dilator, instrument trauma	10%–20%	Ductal stenting across perforation site	Rarely needed: large uncontained leak with sepsis	9,10
IV	Retroperitoneal air only	Excessive air insufflation	<10%	Observation, supportive care	Not indicated	1,11

TTSC, through-the-scope clip; OTSC, over-the-scope clip; FCSEMS, fully covered self-expandable metal stent.

Table 2. Risk Factors for ERCP-Related Perforation

Category	Risk factor	OR or risk measure	Mechanism	Reference
Patient-related	SOD	OR ~3.8	Higher cannulation difficulty	11
	Altered anatomy (Billroth II, Roux-en-Y)	Variable (significantly elevated)	Difficult scope positioning	9
	Advanced age	Increased risk	Fragile tissues, comorbidities	12
	Female sex (in SOD cohorts)	Mixed data	Association unclear	12
Procedure-related	Prolonged procedure time	OR ~1.02 per min	Cumulative trauma risk	11
	Difficult cannulation (>10 min or >15 attempts)	Significantly elevated	Papillary trauma	11
	Precut papillotomy	OR ~3.0	Higher in inexperienced hands	11
	Biliary stricture dilation	OR ~7.2	Fibrotic tissue perforation	11
	Large balloon dilation (EPLBD)	Variable	Risk with oversized balloons	9
	Periampullary diverticulum	Elevated	Challenging anatomy	13

ERCP, endoscopic retrograde cholangiopancreatography; OR, odds ratio; SOD, sphincter of Oddi dysfunction; EPLBD, endoscopic papillary large-balloon dilation.

- Type IV: No full-thickness perforation is evident, but there is retroperitoneal air noted on imaging (often due to excessive air insufflation). This is not a true perforation and needs no additional intervention.

2. Risk factors

Few studies have examined the risk factors for ERCP-related perforations. These risk factors can be broadly subdivided into patient- and procedure-related risk factors (Table 2).

1) Patient-related risk factors

Certain patient characteristics predispose to ERCP-related perforation. Studies have shown that patients undergoing ERCP for sphincter of Oddi dysfunction (SOD) have an elevated risk, possibly due to difficult cannulation and an increased likelihood of needing sphincterotomy. In one study, SOD was associated with an odds ratio of approximately 3.8 for perforation (vs other indications).[11] Altered surgical anatomy is another significant factor: for example, a history of Billroth II gastrectomy or Roux-en-Y reconstruction makes ERCP technically challenging, as the reversed anatomy increases the risk of duodenal wall injury during scope insertion. Even rare conditions like situs inversus or other congenital anatomical variants have been reported as risk factors for ERCP perforation.[9] Older age has also been noted in some series as a risk factor, possibly due to more fragile tissues and comorbidities; some reports suggested female sex might confer higher risk (this was observed in older SOD cohorts with predominantly female patients), though data on gender are mixed.[12] Overall, patient frailty and the presence of significant comorbidities can worsen outcomes if a perforation occurs, even if they do not directly increase perforation incidence.

2) Procedure-related risk factors

- Difficult or prolonged cannulation: Difficult or prolonged cannulation is one major risk element–multiple cannulation attempts (especially >10 minutes or >approximately 15 attempts) significantly increase the risk of papillary trauma and perforation. A prolonged overall procedure time is also associated with higher perforation risk. One analysis reported an odds ratio of approximately 1.02 per additional minute of ERCP.[11]
- Sphincterotomy and precut papillotomy: The majority of ERCP perforations occur during sphincterotomy of the papilla or during precut (access) papillotomy.[14] Extending a sphincterotomy cut too far laterally can result in a retroperitoneal duodenal wall tear (Stapfer type II). Performing an aggressive precut papillotomy also carries a higher risk of perforation (reported OR approximately 3.0 in one analysis),[11] particularly in less experienced hands. Therefore, careful technique and knowing when to abort a difficult cannulation are critical.
- Large-balloon dilation (endoscopic papillary large-balloon dilation): Dilation of the papilla (usually after a partial sphincterotomy) to extract large stones can cause a periampullary perforation if the balloon size is disproportionate to the duct size. This risk is mitigated by avoiding oversizing of the balloon and by performing an adequate sphincterotomy before dilation. Interestingly, performing a complete sphincterotomy alone may carry a higher perforation risk than a combination of sphincterotomy plus balloon dilation, likely because the latter is done in a controlled manner in experienced centers.[9]
- Stricture dilation or intraductal procedures: Dilatation of biliary strictures (malignant or benign) is a known risk factor (odds ratio of approximately 7.2 in one analysis).[11] This is because the guidewire or balloon may perforate the fibrotic duct or duodenal wall at the stricture site. Similarly, forceful instrument manipulation, such as stone extraction in tortuous ducts, or

misuse of devices like baskets or guidewires, can lead to Stapfer type III perforation.

- Challenging anatomy with a side-viewing endoscope: In patients with a periampullary diverticulum or post-surgical duodenal strictures, the standard side-viewing duodenoscope can exert force on the duodenal wall. Intubation of the duodenum should never be forced. If the duodenoscope cannot advance easily into the second portion of the duodenum, there is a risk of a type I perforation from sheer force. In such situations, using pediatric or forward-viewing endoscopes (in Billroth II anatomy) is advisable to minimize stress on the bowel wall.[13]

3. Prevention strategies

Before discussing prevention strategies, it is important to note that ERCP complications can occur unexpectedly even in the hands of highly skilled endoscopists. Thus, the fundamental step for prevention is strict and appropriate patient selection for the procedure. For example, if common bile duct stones are uncertain or bile duct dilation is ambiguous, non-invasive imaging such as endoscopic ultrasound (EUS) or magnetic resonance cholangiopancreatography should be performed prior to ERCP, and ERCP should be reserved for cases where it is absolutely indicated.

1) Pre-procedural considerations

- Sedation and patient positioning: Inadequate sedation may lead to patient movement and inadvertent injury during ERCP. ASGE guidelines (2018) recommend deep sedation or general anesthesia for complex ERCPs so that the endoscopist can perform delicate maneuvers without the patient moving.[15] Proper patient positioning and use of restraints can also help maintain a stable position. ERCP should always be performed with fluoroscopy readily available to detect any abnormal intra-procedural air or contrast leakage. It can be helpful to record a baseline fluoroscopic image at the start (prior to scope insertion) to compare with an image at the end of the procedure, in order to identify any new free air that might indicate a perforation.
- Use of CO_2 insufflation: Room air insufflation can exacerbate the consequences of a perforation by causing tension pneumoperitoneum or pneumoretroperitoneum, and ambient air is absorbed slowly by tissues. In contrast, carbon dioxide (CO_2) is rapidly absorbed. Thus, CO_2 insufflation is strongly recommended by both ESGE (2020) and ASGE (2017) guidelines during ERCP to minimize the risk of compartment syndrome and gas-related complications in the event of a perforation.[1,11]
- Stopping rules and alternatives: When encountering a very difficult cannulation (e.g., multiple failed biliary cannulation attempts by an expert endoscopist), it may be safer to stop rather than persist to the point of perforation. Endoscopists should have a low threshold to abort a cannulation and consider alternative interventions once a predefined limit is reached. Early consideration of alternatives such as EUS-guided biliary drainage (EUS-BD) or percutaneous transhepatic biliary drainage is a proactive strategy to avoid an ERCP-related perforation in a high-risk scenario. Current expert practice is increasingly to utilize EUS-BD (rendezvous or direct transluminal stenting) after a certain number of failed cannulation attempts, rather than proceeding to an aggressive precut in a risky situation–this approach can preempt a catastrophic perforation at the cost of switching techniques.
- Operator expertise and training: Whenever possible, difficult ERCPs (e.g., in patients with altered surgical anatomy or known complex strictures) should be performed in high-volume centers where experienced operators and surgical backup are immediately available. The endoscopist must be trained to recognize and manage complications on the spot. Having an experienced surgeon or interventional radiologist on standby for high-risk cases can expedite appropriate intervention if a complication occurs. Team communication and preparation (e.g., discussing the plan for perforation management before a high-risk case) are invaluable.

2) Procedural techniques and tools

The endoscopist's technique during ERCP plays a pivotal role in prevention:

- Gentle duodenoscope insertion: A common mechanism for Stapfer type I perforation is forceful advancement of the duodenoscope, especially in a patient with post-surgical anatomy. Endoscopists are advised to use extreme caution if the duodenoscope does not easily advance into the second part of the duodenum. In cases of altered anatomy (e.g., Billroth II or other post-gastrectomy anatomy), it is advisable to use a forward-viewing endoscope (such as a pediatric colonoscope with a cap) or even a pediatric enteroscope for cannulation, rather than the standard side-viewing duodenoscope.[13] This can minimize stress on the bowel wall during intubation. Once selective biliary cannulation is successful in such patients, performing balloon dilation of the papilla (instead of a standard papillotomy)

can be considered to achieve access or therapy while reducing the risk of a large papillary incision. This approach is often useful in scenarios like Billroth II anatomy or after certain surgeries (e.g., prior fundoplication) where standard orientation is challenging. In all cases, avoid forceful pushing of the scope; if significant resistance is encountered at any point, it is prudent to pause and reposition rather than persist with brute force.

- Controlled sphincterotomy technique: To prevent periampullary perforations (Stapfer type II), sphincterotomy should be performed with meticulous attention to anatomical landmarks. The cut should remain within the intramural portion of the bile duct; distinguishing the roof of the papilla (toward 12 o'clock) from the lateral duodenal wall is critical. Endoscopists should make gradual, stepwise cuts and avoid extending the sphincterotomy too far laterally into the duodenal wall. If the papillary orientation is unclear or a prior sphincterotomy scar is present, proceeding cautiously or using adjunct techniques (such as a needle-knife sphincterotomy over a pancreatic stent) can reduce the risk. When a full sphincterotomy is absolutely required (for example, to extract a large biliary stone), recognize that the risk of perforation increases if the incision extends beyond the upper margin of the papilla. One useful method is to inject contrast to slightly distend the bile duct, which makes the papilla bulge and delineates the roof of the papilla, then use a balloon or scope traction to expose the upper margin before cutting. If a precut papillotomy (access sphincterotomy) or infundibulotomy is needed, it should begin with only a shallow incision (into the submucosa) rather than a full cut from the outset. Once the white biliary wall or submucosal layer is exposed, the incision can be carefully extended to open the duct without going full thickness. This staged approach minimizes the chance of an uncontrolled duodenal wall incision.
- Judicious use of dilation: For large bile duct stones, endoscopic papillary large-balloon dilation should only be performed after a partial sphincterotomy and by sizing the balloon to the patient's distal bile duct diameter. Over-dilation (using a balloon larger than the duct) can tear the papilla or periampullary duodenum. Balloon inflation should always be done under fluoroscopic control, and the recommended inflation pressure or duration should not be exceeded. Rapid or uncontrolled balloon inflation can increase the risk of perforation; a slow, controlled inflation is safer. If a biliary stricture is present and the balloon "waist" does not disappear despite prolonged inflation, do not persist with further pressure, as continuing to dilate may cause a tear. Particularly in cases where the ampulla is small or located within a periampullary diverticulum, the risk of perforation during a standard sphincterotomy is elevated. In such scenarios, performing only a minimal sphincterotomy (just enough to allow subsequent dilation) or opting for balloon dilation alone (instead of a full cut) may be preferable to mitigate perforation risk.
- Guidewire handling: Many small perforations are guidewire-induced (Stapfer type III). These are often of minimal consequence, but careful technique can further reduce their occurrence. Guidewires should always be advanced under fluoroscopic visualization and never forced against resistance. If a guidewire is not following the expected ductal course or meets resistance, it should be withdrawn and repositioned; forcing a misdirected wire can create a false passage or perforation. Coiling of the wire in an unusual location on fluoroscopy is an indicator that it may be out of the duct–a cue to pull back immediately.
- Prophylactic measures: In contrast to post-ERCP pancreatitis, there are no medications proven to prevent perforation. However, ensuring that all devices (sphincterotomes, dilating balloons, etc.) are of appropriate size and in good working condition is important. In select high-risk cases, some experts advocate prophylactic placement of a small pancreatic stent before a difficult biliary precut to maintain orientation and provide a landmark.[16] This is primarily intended to prevent pancreatitis and guide biliary access, rather than directly preventing perforation, but it may indirectly reduce uncontrolled cutting in the papillary area.

In summary, preventing ERCP-related perforation hinges on sound procedural judgment and technique. The endoscopist should constantly keep in mind three key principles: (1) do not force the endoscope against resistance; (2) perform sphincterotomy only with a clear view and understanding of papillary anatomy; and (3) tailor any dilation or intervention to the patient's anatomy and duct size. If these principles cannot be satisfied (for example, the anatomy precludes a safe sphincterotomy or cannulation), it is prudent to pause or even abort the procedure rather than push forward unsafely. If careful attention is paid to early warning signs of problems, such as unexpected extraluminal air observed during fluoroscopy, it is possible to take immediate mitigating measures and effectively "stop it early" in the case of an ongoing perforation.

4. Management of ERCP-related perforation: multidisciplinary coordination

Early detection of an ERCP-induced perforation is critical for successful management. The clinical presentation can be subtle initially—patients may experience only mild epigastric or back pain, tachycardia, or low-grade fever during or shortly after the procedure. Because only a minority of perforations are recognized during the ERCP procedure itself (approximately 27% in one series),[17] endoscopists must maintain a high index of suspicion post-procedure. A careful fluoroscopic examination at the end of the ERCP (looking for extraluminal air or contrast leakage) is advisable to aid on-table diagnosis. If a perforation is even suspected, prompt multidisciplinary assessment is required, involving gastroenterologists, surgeons, and interventional radiologists.

Management of an ERCP-related perforation is guided by the type and severity of the injury, the patient's clinical condition, and the timing of diagnosis. Broadly, three tiers of management exist (often used in combination): conservative medical management, endoscopic therapy, and surgical intervention. Current consensus from ESGE (2020) and recent systematic reviews is that many ERCP perforations can be managed nonoperatively if recognized early and if the leak is contained and well-controlled, especially for Stapfer types II and III injuries.[6,11]

1) Conservative (non-interventional) management

All patients with a suspected ERCP perforation, regardless of type, should receive prompt conservative therapy as the initial baseline treatment. Conservative management includes: strict bowel rest (*nil per os*), aggressive intravenous fluid resuscitation, broad-spectrum intravenous antibiotics, and close clinical monitoring. Antibiotic coverage should target gastrointestinal flora (gram-negatives, enterococci, anaerobes) to prevent or treat contamination that could lead to peritonitis, abscess, or sepsis. In addition, gastric decompression with a nasogastric tube (for duodenal perforations) or a nasobiliary drain (for major duct leaks) can reduce further leakage of enteric contents. Proton pump inhibitors are often given to decrease gastric acid secretion, theoretically minimizing chemical irritation at a perforation site in the duodenum.

Conservative management alone (without any endoscopic or surgical intervention) is most appropriate for Stapfer type IV injuries (isolated retroperitoneal air without contrast extravasation) and for small type III ductal leaks that show only minimal contrast leakage and no signs of sepsis or peritonitis. In these scenarios, the perforation often seals spontaneously. For example, a tiny guidewire perforation of the bile duct may require only antibiotics and supportive care, with the expectation that it will heal on its own. Serial physical examinations and imaging (such as repeat computed tomography scans) are used over 24–48 hours to ensure that no fluid collections are developing and that free air is not expanding. Patients should remain hospitalized for observation during this period.

If the patient remains hemodynamically stable, without fever, and with a benign abdominal exam (no peritoneal signs), purely conservative management can be continued. Published studies report successful non-surgical therapy rates ranging from approximately 50% to as high as 90% in carefully selected cases.[6,10,18,19] Key prognostic indicators for success include: early detection (within a few hours of occurrence), a contained leak (e.g., primarily retroperitoneal leakage rather than free intraperitoneal spillage), and the absence of systemic inflammatory response syndrome or organ failure at presentation.[6] It should be noted that even when endoscopic or surgical interventions are required, the above conservative measures are still instituted as adjunct therapy. For instance, after endoscopic clipping of a duodenal perforation, the patient should still be managed with antibiotics, bowel rest, and serial exams as described. Likewise, if a covered stent is placed for a papillary perforation (Stapfer II), the patient is kept *nil per os* and closely monitored while the stent diverts bile away from the leak. In other words, conservative management forms the foundation of care to which other therapies are added as needed.

2) Endoscopic management

The advent of advanced endoscopic devices and techniques has dramatically improved our ability to treat many perforations without surgery. If a perforation is recognized intraprocedurally (the ideal scenario), immediate endoscopic therapy can often contain the injury. Even when a perforation is identified shortly after the procedure, re-entry with an endoscope (or a prompt second therapeutic ERCP) can be attempted in a hemodynamically stable patient to address the perforation endoscopically.

(1) Endoscopic closure of perforation defects

For a luminal duodenal wall perforation (Stapfer type I), the primary goal is to close the defect endoscopically if possible. A through-the-scope clip can be applied to small perforations, typically those ≤10 mm, to approximate the edges of the tear (Fig. 2).[20] For larger defects (approximately 1 to 2 cm), specialized techniques are employed. One option is an over-the-scope clip (OTSC) device, which is a cap-mounted clip that can grasp full-thickness tissue; OTSCs have been used successfully for duodenal perforations up to about 20 mm in size (Fig. 3).[20] Case series have

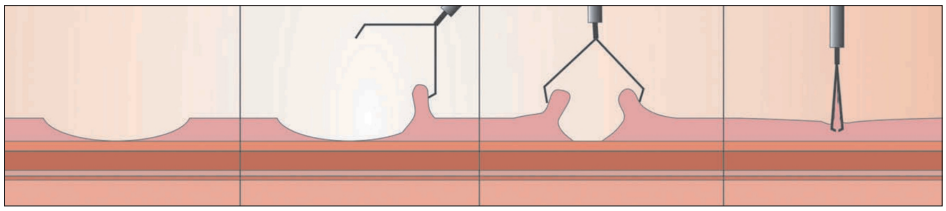


Fig. 2. Mechanism of action of through-the-scope clip. Small or oval elongated lesions are clipped in a zipper-like fashion, starting in one corner and working clip by clip to the other corner. With every clip that is placed, the edges close to the clip are pulled a bit closer to each other, allowing subsequent clips to more easily reach the opposite wound margins. Reproduced from Turan AS, *et al.* Expert Rev Med Devices 2019;16:493-501.[20]

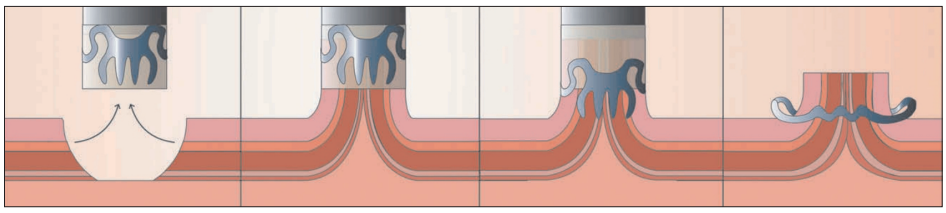


Fig. 3. Mechanism of action of over-the-scope clip. The target tissue is suctioned into the cap, and anchor devices are used to grasp and pull the margins inward. When the clip is deployed, its teeth may slightly displace the tissue outward. Reproduced from Turan AS, *et al.* Expert Rev Med Devices 2019;16:493-501.[20]

reported success rates of endoscopic clipping–using either multiple through-the-scope hemoclips or an OTSC–for duodenal perforations under approximately 13 mm ranging, from roughly 88% to 100%.[21]

Another closure method is the so-called "loop-and-clip" (or "clip-and-string") technique: multiple standard clips are placed circumferentially around the perforation edges, and then a nylon endoloop is lassoed around the grouped clips and tightened, cinching the defect closed like a purse-string (Fig. 4).[22] This can be effective for larger irregular tears, but it is technically demanding and not widely practiced; importantly, attempting this should not unduly delay surgery if it is not quickly successful. In some advanced centers, endoscopic suturing devices are also available and have been used to stitch larger perforations, though data on their use specifically in ERCP-related perforations are still limited. Notably, variations combining techniques have been described. In select cases, tissue sealants such as fibrin glue have been applied alongside endoclips to reinforce the closure of a duodenal perforation.[23] While not a first-line approach, this combination therapy (clips plus glue) has been reported in cases where conventional clipping alone was insufficient, offering an extra tool for achieving a seal.[24,25]

Any endoscopic closure attempt should be followed by careful assessment (e.g., contrast injection under fluoroscopy during the ERCP, or a prompt post-procedure computed tomography scan with oral contrast) to confirm that the leak is truly sealed. Early endoscopic closure, when achievable, has clear benefits: it stops ongoing leakage of luminal contents, which can prevent the development of peritonitis, and it has been associated with a quicker return to oral intake and shorter hospital stay. One study noted that prompt endoscopic treatment of a duodenal perforation led to significantly faster recovery compared to delayed or no endoscopic intervention.[17] Thus, if a Stapfer type I perforation is detected immediately (e.g., by directly visualizing a wall defect endoscopically or seeing contrast extravasation fluoroscopically), many experts will attempt endoscopic clipping or closure on the spot during the index ERCP.

(2) Biliary and pancreatic duct stenting (internal diversion)

For injuries involving the papillary/ampullary region or ductal leaks (Stapfer types II and III), the cornerstone of endoscopic management is internal diversion of bile and pancreatic secretions away from the perforation site. This is typically achieved by endoscopic stenting across the papilla. In the case of a sphincterotomy-related periampullary duodenal perforation (Stapfer II), placing a fully covered self-expandable metal stent (FCSEMS) bridging the ampulla can effectively seal the area and divert bile flow beyond the leak site. Comparative studies have shown that using FCSEMS in this setting leads to better pain control, shorter hospital stays, and fewer retroperitoneal abscesses compared to traditional external drainage (e.g., nasobiliary drains).[26] For example, a comparative series of 25 patients with Stapfer II perforations found that outcomes were improved in those managed with FCSEMS versus nasobiliary drainage (with faster recovery and fewer complications).

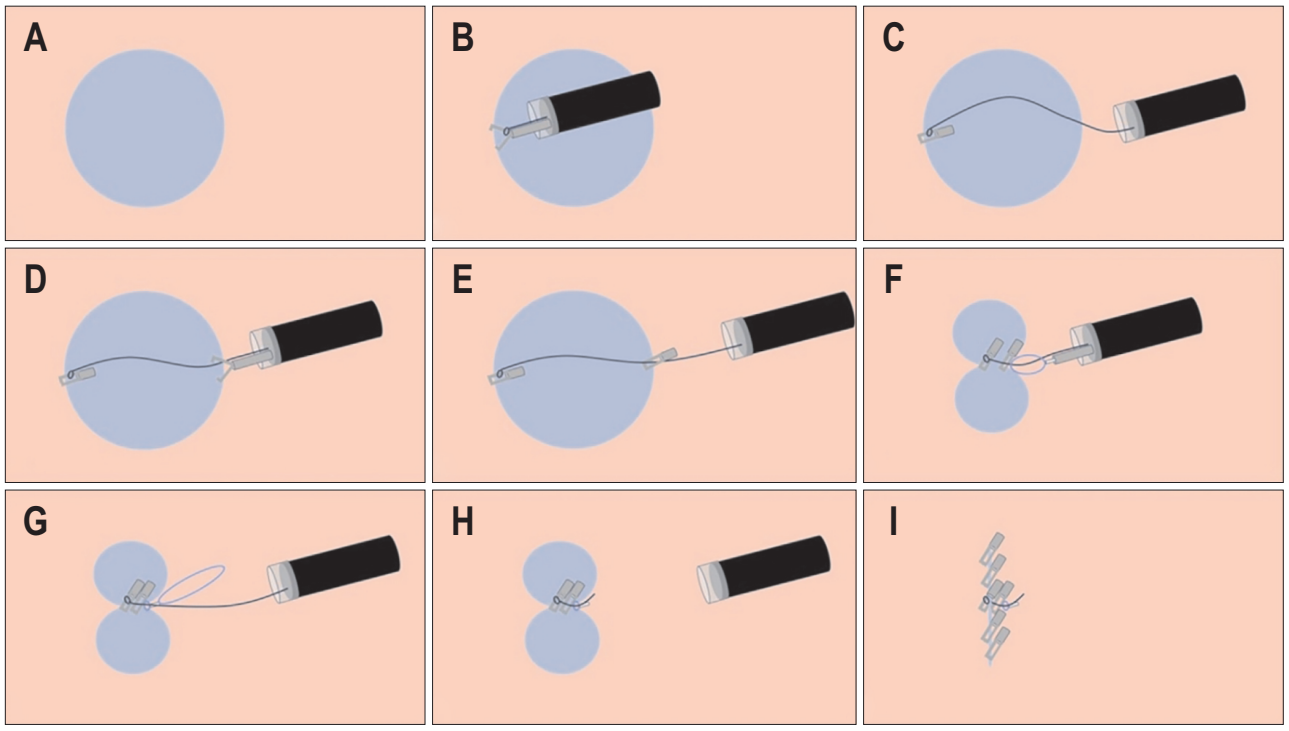


Fig. 4. Schematic diagram of the loop-and-clip technique for mucosal defect closure. (A) Mucosal defect; (B) a clip with a string placed at the distal margin of the defect; (C) the string emerging from the endoscope channel; (D) a second clip hooked onto the string; (E) the second clip fixed to the proximal margin; (F) insertion of a detachable snare along the string; (G) tightening and deployment of the snare to form a knot; (H) cutting of the string and snare with a loop cutter; (I) placement of additional clips to achieve complete closure. Reproduced from Minato Y, *et al.* VideoGIE 2024;9:320-323.[22]

Plastic stents can also be used (and historically were more common), but a large-caliber plastic stent may not tamponade the leak as effectively as a covered metal stent.[7] Recent meta-analyses have confirmed the superiority of FCSEMS over conventional management for type II perforations.[8]

For ductal leaks (Stapfer III), placing a stent in the injured bile or pancreatic duct (traversing the leak) helps reduce intraductal pressure and diverts flow, facilitating sealing of the perforation. For example, a guidewire-induced perforation of the common bile duct can be managed by placing a biliary stent past the leak point. Studies report Stapfer type III injuries have a >95% successful non-surgical treatment rate, with a generally benign course if managed appropriately.[7,8,26] If perforation (type II or III) is not detected during the initial ERCP but symptoms such as retroperitoneal free air or abdominal pain appear on subsequent imaging studies, re-ERCP for stent placement may still be beneficial if the patient's condition is stable enough to tolerate the procedure. There are reports of clinical success even when stents are placed a day or two after a delayed-recognition Stapfer II perforation.[4,26] However, if there is evidence of widespread infection (sepsis) or if the window for a relatively straightforward endoscopic repair has passed, one must not delay moving to surgical management.

(3) Adjunctive endoscopic measures

In addition to direct closure or diversion, endoscopists can perform decompression and drainage procedures endoscopically to aid management. For example, if imaging shows a contained retroperitoneal fluid collection forming as a result of a perforation, an attempt can be made at EUS-guided transluminal drainage of the collection, creating an internal drainage route into the stomach or duodenum. This approach is analogous to how post-pancreatitis fluid collections are managed, and it can be an alternative to percutaneous drains for accessible collections (assuming infection is controlled). As another adjunct, endoscopists may place nasogastric or nasojejunal tubes endoscopically for continuous suction to keep the duodenum empty and dry; this is often done during the index ERCP if a perforation is identified, to minimize ongoing duodenal fluid leakage. Overall, the development of endoscopic management techniques has markedly reduced the need for emergency surgery in ERCP perforations. Current guidelines (e.g., ESGE 2020) suggest that the majority of ERCP-related periampullary or ductal perforations can be treated

without surgery, and that endoscopic therapy should be attempted whenever feasible.[6,11] The key exceptions that still require primary surgical management are discussed below. Importantly, any attempt at endoscopic therapy should not unduly delay surgery in a patient who is deteriorating; close communication between the endoscopist and surgeon is essential, and they should jointly decide on the best approach based on the patient's real-time clinical status.

3) Surgical management

Surgery remains a life-saving intervention for ERCP perforations that cannot be adequately contained by conservative or endoscopic means. Indications for surgical exploration include: (1) free intraperitoneal leakage of fluid or contrast (especially Stapfer type I perforations) that cannot be closed endoscopically; (2) evidence of diffuse peritonitis or sepsis despite non-operative measures; (3) imaging showing a large contrast extravasation or a large defect; or (4) any clinical deterioration (e.g. persistent hypotension, tachycardia, or organ failure) in the setting of a known perforation.

Early surgical consultation should be obtained as soon as a significant perforation is recognized or strongly suspected. If the decision for surgery is made, earlier intervention (within a few hours of perforation) is associated with better outcomes. A systematic review noted that when surgery for a Stapfer I duodenal perforation was delayed beyond 24 hours, patients had more complex procedures and higher mortality rates.[4]

The surgical procedure is typically an exploratory laparotomy (though laparoscopic repair has been reported in select stable cases with experienced minimally invasive surgeons). For a duodenal (type I) perforation, surgery usually involves primary repair of the duodenal tear (often with an omental patch reinforcement) and thorough abdominal washout to prevent abscess formation. Wide drainage with placement of drains is performed. In some cases of large duodenal defects or delayed diagnosis, surgeons have performed a duodenostomy or even a duodenal diversion (such as a gastrojejunostomy or pyloric exclusion) to protect the area.

The choice of procedure depends on factors like the size of the defect, time elapsed, and degree of contamination. If the ampullary area is severely damaged, a biliary drainage (T-tube or surgical bypass) and feeding jejunostomy might be added. In patients with prior Billroth II surgery, a posterior approach (trans-mesocolic) to the duodenum can facilitate better exposure and drainage of the retroperitoneum, as noted in some surgical series.[10,18]

In cases of Stapfer type II perforation, conservative treatment (e.g., internal or external drainage via bile duct stenting, pancreatic duct stenting, or gastric decompression) is more commonly effective than immediate surgery. However, if a perforation is not detected early and surgical procedures are performed on a delayed basis (e.g., unrecognized injury during ERCP), the condition may progress to requiring surgery. Early detection of perforation is thus the most critical factor. If there is no improvement with conservative treatment within 24 hours, surgical intervention becomes necessary, as delayed treatment or diagnosis may result in poor outcomes.[9] The operative goal is to ensure adequate diversion and drainage of biliary and pancreatic contents. This could involve surgical closure of any duodenal wall defect if present, plus placement of a T-tube in the common bile duct or performing a biliary-enteric diversion (e.g., hepaticojejunostomy) if the ampullary region is severely injured. However, surgical intervention in Stapfer type II is typically reserved for patients who have developed diffuse retroperitoneal abscess or peritonitis despite endoscopic stenting.[5]

Postoperatively, intensive care monitoring is often needed for severe perforations, and patients may require prolonged antibiotic courses and nutritional support (either total parenteral nutrition or feeding via a jejunal tube) during recovery. Even with successful surgical management, ERCP-related perforations carry significant morbidity, and careful postoperative follow-up is necessary to watch for complications such as fistula formation or intra-abdominal abscesses.

In summary, surgery is the definitive management for ERCP-related perforations that cannot be contained by other means. It remains an essential part of the algorithm, especially for Stapfer type I perforations or any scenario with diffuse peritonitis. The decision to operate is based on clinical judgment–factors such as persistent pain, fever, tachycardia, rising inflammatory markers, or failure of the patient to improve on conservative measures should prompt surgical intervention. A commonly proposed management algorithm considers the Stapfer classification and clinical status: type I injuries usually proceed to surgery (unless successfully clipped immediately); type II and III injuries are managed initially with non-surgical measures unless there is a major leak or sepsis; and any clinical deterioration at any point is an indication for surgery. A proposal for a diagnostic and treatment algorithm is shown in Fig. 5

4) Future perspectives

The management of ERCP-related perforation continues to evolve, and future developments hold promise for further reducing both incidence and morbidity. Several areas of advancement and research are notable: The follow-

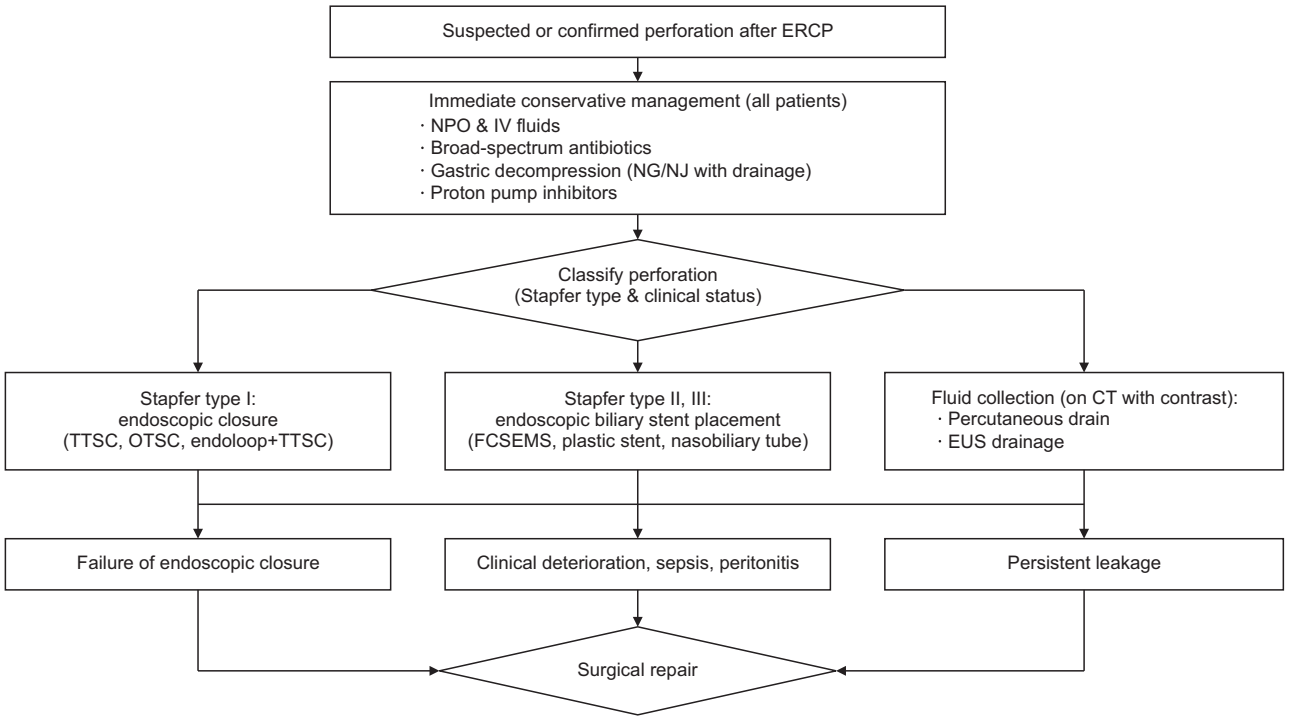


Fig. 5. Proposed management algorithm for ERCP-related perforation. Following confirmation or suspicion of perforation, all patients undergo immediate conservative treatment. The patients are subsequently classified on the basis of Stapfer type and clinical condition, which can guide decision-making among endoscopic closure, stenting, or surgical intervention. Criteria for escalation to surgery include clinical deterioration (e.g., persistent hypotension, tachycardia, or organ failure), sepsis, and peritonitis. ERCP, endoscopic retrograde cholangiopancreatography; NPO, *nil per os*; IV, intravenous; NG, nasogastric; NJ, nasojejunal; TTSC, through-the-scope clip; OTSC, over-the-scope clip; FCSEMS, fully covered self-expandable metal stent; CT, computed tomography; EUS, endoscopic ultrasound.

ing perspectives reflect expert opinion rather than formal guideline recommendations.

- Improved endoscopic technology: The trend in therapeutic endoscopy is toward devices that can manage even full-thickness gastrointestinal defects. Future iterations of endoscopic clips and closure systems are likely to be stronger, easier to deploy, and able to close larger perforations. For instance, OTSC technology is being refined, and novel clipping devices (bear-claw designs, articulated clips) may increase success rates of endoscopic closure.[21] Endoscopic suturing, currently available in some centers, could become more widely adopted for duodenal perforations–allowing secure closure of even larger defects than clips alone.[27] In addition, tissue sealants and glues might play a complementary role: while not first-line for ERCP perforation currently, research into endoscopic use of fibrin glue or other sealants could potentially offer an extra tool for small contained leaks.
- Devices to reduce perforation risk: On the preventive side, innovation in duodenoscope design may help reduce mechanical stress. The development of single-use (disposable) duodenoscopes, primarily motivated by infection control, might have secondary benefits–these scopes tend to be lighter and potentially more maneuverable in difficult anatomy, possibly lessening force on the bowel wall.[28] Concepts such as pressure sensors on the endoscope or real-time monitoring of wall stress have been proposed, though they are not yet a reality. Another area is cannulation-assist devices: for example, wire-guided cannulation techniques and improved papillotomes could minimize inadvertent contrast injection or duct trauma that sometimes lead to perforation.
- Alternative techniques (EUS-guided interventions): The rise of EUS-guided biliary and pancreatic drainage offers a viable alternative when standard ERCP is considered high-risk or has failed.[29] In the future, we may see more liberal use of primary EUS-BD in anatomies where ERCP is perilous (e.g., patients with gastric bypass surgery), thereby avoiding ERCP-related perforation entirely in those cases. If difficult cannulation is encountered, earlier conversion to EUS-BD could prevent the repeated instrumentation that sometimes leads to perforation. ASGE guidelines (2024) already include EUS-BD as a salvage option.[29] Ongoing innovations in EUS-guided anastomosis (e.g., lumen-apposing metal stents) will likely make this ap-

proach even safer and more common.

CONCLUSIONS

To achieve the best outcomes in ERCP-related perforations, it is most important to prevent this complication whenever possible and to be prepared to manage it effectively if it occurs. Thorough patient selection and specialized technical skills remain key elements of prevention. If a perforation does occur, early detection and prompt implementation of a stratified treatment strategy are critical. In practice, this means starting with conservative measures and progressing stepwise to endoscopic or surgical intervention as needed to maximize the likelihood of success. Recent advancements in endoscopic closure and diversion techniques have significantly improved our ability to treat many perforations without surgery, representing a major advance in management. However, careful judgment is necessary to determine when surgical treatment is required and to avoid delays in operative intervention. By rigorously applying preventive strategies, ensuring early recognition, and using a multidisciplinary, patient-tailored approach, healthcare providers can greatly reduce the impact of ERCP-related perforations and improve patient safety in the era of advanced endoscopic therapy.

CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

AUTHOR CONTRIBUTIONS

Study concept and design: E.S.L., J.L. Data acquisition: E.S.L. Data analysis and interpretation: E.S.L. Drafting of the manuscript: E.S.L. Critical revision of the manuscript for important intellectual content: J.L. Statistical analysis: E.S.L. Administrative, technical, or material support: E.S.L. Study supervision: J.L. Approval of final manuscript: all authors.

ORCID

Eaum Seok Lee https://orcid.org/0000-0002-5689-9567
Jonghyun Lee https://orcid.org/0000-0002-9752-5860

DATA AVAILABILITY STATEMENT

Data sharing is not applicable as no new data were created or analyzed in this study.

REFERENCES

1. Dumonceau JM, Kapral C, Aabakken L, et al. ERCP-related adverse events: European Society of Gastrointestinal Endoscopy (ESGE) guideline. Endoscopy 2020;52:127-149.
2. Langerth A, Isaksson B, Karlson BM, Urdzik J, Linder S. ERCP-related perforations: a population-based study of incidence, mortality, and risk factors. Surg Endosc 2020;34:1939-1947.
3. Stapfer M, Selby RR, Stain SC, et al. Management of duodenal perforation after endoscopic retrograde cholangiopancreatography and sphincterotomy. Ann Surg 2000;232:191-198.
4. Boonstra K, Voermans RP, van Wanrooij RL. Management of iatrogenic perforations during endoscopic interventions in the hepato-pancreatico-biliary tract. Best Pract Res Clin Gastroenterol 2024;70:101890.
5. Cirocchi R, Kelly MD, Griffiths EA, et al. A systematic review of the management and outcome of ERCP related duodenal perforations using a standardized classification system. Surgeon 2017;15:379-387.
6. Tarallo M, Crocetti D, Coppola A, et al. Endoscopic retrograde cholangiopancreatography-related adverse events: what is the role of surgery today? World J Gastrointest Surg 2025;17:107385.
7. Shi D, Guo S, Bao Y, Wang Q, Pan W. Diagnosis and management of type II endoscopic retrograde cholangiopancreatography-related perforations: a multicenter retrospective study. BMC Gastroenterol 2024;24:241.
8. Saeed A, Yousuf S, Zain A, et al. Efficacy of fully covered self-expandable metal stents and comparison with conventional management for ERCP-related type II perforations: a systematic review and meta-analysis. Gastrointest Endosc 2025;102:738-742.
9. Morgan KA, Fontenot BB, Ruddy JM, Mickey S, Adams DB. Endoscopic retrograde cholangiopancreatography gut perforations: when to wait! When to operate! Am Surg 2009;75:477-484.
10. 10 Rabie ME, Mir NH, Al Skaini MS, et al. Operative and non-operative management of endoscopic retrograde cholangiopancreatography-associated duodenal injuries. Ann R Coll Surg Engl 2013;95:285-290.
11. Paspatis GA, Arvanitakis M, Dumonceau JM, et al. Diagnosis and management of iatrogenic endoscopic perforations: European Society of Gastrointestinal Endoscopy (ESGE) po-

sition statement: update 2020. Endoscopy 2020;52:792-810.
12. Chandrasekhara V, Khashab MA, Muthusamy VR, et al. Adverse events associated with ERCP. Gastrointest Endosc 2017;85:32-47.
13. Park TY, Bang CS, Choi SH, et al. Forward-viewing endoscope for ERCP in patients with Billroth II gastrectomy: a systematic review and meta-analysis. Surg Endosc 2018;32:4598-4613.
14. Masci E, Toti G, Mariani A, et al. Complications of diagnostic and therapeutic ERCP: a prospective multicenter study. Am J Gastroenterol 2001;96:417-423.
15. Early DS, Lightdale JR, Vargo JJ, et al. Guidelines for sedation and anesthesia in GI endoscopy. Gastrointest Endosc 2018;87:327-337.
16. Qi Y, Li Q, Yao W, Wu Y, Li N. Precut over a pancreatic duct stent versus transpancreatic precut sphincterotomy for difficult biliary cannulation in endoscopic retrograde cholangiopancreatography: a retrospective cohort study. Dig Dis Sci 2024;69:3962-3969.
17. Bill JG, Smith Z, Brancheck J, et al. The importance of early recognition in management of ERCP-related perforations. Surg Endosc 2018;32:4841-4849.
18. Zhu G, Hu F, Wang C. Recent advances in prevention and management of endoscopic retrograde cholangiopancreatography-related duodenal perforation. Wideochir Inne Tech Maloinwazyjne 2021;16:19-29.
19. Samara AA, Diamantis A, Perivoliotis K, et al. Surgical versus non-operative initial management of post-endoscopic retrograde cholangiopancreatography perforation: a systematic review and meta-analysis. Ann Gastroenterol 2022;35:95-101.
20. Turan AS, Ultee G, Van Geenen EJ, Siersema PD. Clips for managing perforation and bleeding after colorectal endoscopic mucosal resection. Expert Rev Med Devices 2019;16:493-501.
21. Weiland T, Fehlker M, Gottwald T, Schurr MO. Performance of the OTSC System in the endoscopic closure of iatrogenic gastrointestinal perforations: a systematic review. Surg Endosc 2013;27:2258-2274.
22. Minato Y, Ohata K, Kimoto Y, et al. A modified approach for closing endoscopic submucosal dissection defects using clip with line pulley securing technique and endoloop. VideoGIE 2024;9:320-323.
23. Samarasena JB, Nakai Y, Park DH, Iwashita T, Chang K. Endoscopic closure of an iatrogenic duodenal perforation: a novel technique using endoclips, endoloop, and fibrin glue. Endoscopy 2012;44 Suppl 2 UCTN:E424-e425.
24. Rogalski P, Daniluk J, Baniukiewicz A, Wroblewski E, Dabrowski A. Endoscopic management of gastrointestinal perforations, leaks and fistulas. World J Gastroenterol 2015;21:10542-10552.
25. Cho KB. The management of endoscopic retrograde cholangiopancreatography-related duodenal perforation. Clin Endosc 2014;47:341-345.
26. Bozbiyik O, Cetin B, Gumus T, Tekin F, Uguz A. Fully covered self-expandable metal stent for intraprocedural or late-diagnosed type-II endoscopic retrograde cholangiopancreatography-related perforations. BMC Gastroenterol 2022;22:385.
27. Hoffman A, Atreya R, Rath T, Dorlöchter C, Neurath MF. Endoscopic management of perforations, gastrointestinal leaks, and fistulae. Visc Med 2025;41:1-12.
28. Peter S, Bang JY, Varadarajulu S. Single-use duodenoscopes: where are we and where are we going? Curr Opin Gastroenterol 2021;37:416-420.
29. Pawa S, Marya NB, Thiruvengadam NR, et al. American Society for Gastrointestinal Endoscopy guideline on the role of therapeutic EUS in the management of biliary tract disorders: summary and recommendations. Gastrointest Endosc 2024;100:967-979.