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Strategies for achieving successful cannulation in ERCP: A technical overview

Ismail A and Abdelwahab MM *et al.* ERCP cannulation

Alaa Ismail, Maya Magdy Abdelwahab, Mubin Ozercan, Osama Elnahas, Ibrahim Halil Bahcecioglu, Mehmet Yalniz, Ahmed Tawheed

Abstract

Endoscopic Retrograde Cholangiopancreatography (ERCP) is a vital diagnostic and therapeutic technique used in evaluating and treating biliary and pancreatic disorders. Since its inception in the late 20th century, ERCP has transitioned from a mostly diagnostic instrument to a chiefly interventional procedure, owing to the emergence of less invasive imaging techniques like magnetic resonance cholangiopancreatography (MRCP) and endoscopic ultrasonography (EUS). Successful biliary cannulation is the most important and difficult step of the procedure. However, there are many challenges of cannulation, such as the anatomy of the major duodenal papilla, the direction of the common bile duct and pancreatic duct in the ampulla of Vater, the presence of periampullary diverticula, and scope position. Advanced techniques for cannulation are necessary when the basic techniques fail. Double guidewire, precut methods, and transpancreatic sphincterotomy are examples of these advanced techniques. **This review aimed to summarize the challenges of biliary cannulation and the tips of cannulation techniques**

Key Words: **Biliary diseases; Cannulation; Common bile duct; Endoscopic Retrograde Cholangiopancreatography; Sphincterotomy; Needle Knife; Pancreatic duct**

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Core Tip: Endoscopic Retrograde Cholangiopancreatography (ERCP) is a crucial diagnostic and therapeutic technique for biliary and pancreatic disorders. Challenges include anatomy, duct direction, diverticula, and scope position. Advanced techniques are needed for successful cannulation. In this review, we discuss the challenges and the advanced techniques of cannulation.

INTRODUCTION

Endoscopic retrograde cholangiopancreatography (ERCP) is a complex endoscopic technique for diagnosing and treating pancreaticobiliary diseases. The role of ERCP in managing biliary and pancreatic disorders has evolved significantly since its introduction in the late 1960s. Initially developed as a diagnostic tool, ERCP has transitioned into a primarily therapeutic procedure, driven by advancements in technology, techniques, and a deeper understanding of biliary and pancreatic pathophysiology. This evolution has transformed ERCP into a cornerstone of modern gastroenterology, offering minimally invasive solutions for complex disorders.

Successful biliary cannulation is the fundamental and most difficult step in ERCP, with difficult biliary cannulation as the most devastating challenge for endoscopists. The first successful biliary cannulation was achieved through the collaborative efforts of obstetrician William McCune and the surgical team at George Washington University, utilizing an Eder fiberoptic duodenoscope equipped with both forward and side lenses.[1] Following McCune's work, Oi[1,2] developed a side-viewing fiberoptic duodenoscope with a cannula manipulation feature. However, the therapeutic use of ERCP only came to light with the work of researchers at Erlangen in Germany and Kawai in Japan, who reported the first biliary sphincterotomy.[1,3]

ERCP is indicated for a wide range of clinical conditions including but not limited to biliary obstruction due to stones, infection, or parasites (eg. Biliary ascariasis); types 1 and 2 sphincter of Oddi dysfunction; tissue sampling of biliary or pancreatic ductal system disease; investigation of pancreatic cancer, pancreatitis of unknown cause; biliary stenting for strictures and leakage; drainage of pancreatic pseudo cysts; balloon dilation of the duodenal papilla and ductal strictures; and advanced therapeutic interventions for biliary tract malignancies, such as photodynamic therapy (PDT) and radiofrequency ablation (RFA) for cholangiocarcinoma.

The success rates of ERCP cannulation vary significantly among endoscopists, with failure rates ranging from 5 to 49%, with a mean rate of 20% in experienced endoscopists[4] to as high as 50% in early attempts, as documented by McCune.[1] This

variability underscores the technical challenges associated with achieving successful cannulation, which remains a critical step in the overall success of ERCP procedures. Herein, we will discuss the technical aspects and details of cannulating the papilla in ERCP, along with useful tools to improve the success rate of ERCP cannulation.

Anatomy of the Major Duodenal Papilla and Biliary System

The major duodenal papilla, also known as the papilla of Vater, is the site where the pancreatic duct and bile duct unite to form the ampulla of Vater before entering the duodenum. Endoscopically, the papilla generally projects over 1 cm into the duodenum and is seen as a hemispherical or oval structure. It is often accompanied by a circular “hooding” fold on the oral side and a vertical “frenulum” on the anal side, features that help indicate its position, even when the papilla is partially hidden or is associated with a diverticulum.[5]

At the distal end of the biliary system, the common ¹⁴ bile duct and pancreatic duct typically merge to form a short common channel within the duodenal wall, though in some cases the ducts may join only at the papillary orifice or even drain separately into the duodenum, as shown in figure 1.[6]

Cannulation Equipment and Accessories

Duodenoscopes

Duodenoscopes are the fundamental endoscopic instruments used during ERCP procedures. They provide direct visualization of the duodenum and major papilla and serve as the basic platform through which all other devices—guidewires, and cannulation catheters are introduced and manipulated.

Cannulation Catheters

Standard cannulation catheters used in ERCP are typically 5F to 7F in size and are fabricated from Teflon. They feature either straight or ultra-tapered tips that can accommodate a 0.035-inch guidewire.[7] These catheters come in various

configurations—single-, double-, or triple-lumen—with the double-lumen variants allowing simultaneous contrast injection (via a Luer lock or side-arm adaptor) and guidewire manipulation.[8] Many endoscopists favor ultra-tapered (5F-4F-3F) designs for the cannulation of bile and pancreatic ducts, particularly when smaller-caliber guidewires (down to 0.018 inch) are indicated. In select cases, a separate 3F cannula may be utilized through a standard device to further reduce the effective diameter for challenging cannulations.[9]

Sphincterotomes

Sphincterotomes differ from standard cannulation catheters by incorporating an electrosurgical cutting wire at the distal tip, which enables them to perform therapeutic sphincterotomy.[8] These devices are available in various tip lengths (ranging from 3 to 20 mm) and are offered in double- or triple-lumen designs. Some models are rotatable or feature a short-wire configuration to maximize maneuverability. Advanced modifications include hybrid sphincterotomes with built-in stone extraction balloons and specialized designs for patients with surgically altered anatomies (for example, devices with reversed or S-shaped cutting wire configurations).[10]

Guidewires

Guidewires are critical accessories for achieving deep ductal cannulation and facilitating various therapeutic interventions. They are available in multiple configurations—from conventional and hydrophilic to nitinol and hybrid designs—with diameters ranging from 0.018 to 0.035 inches.[11] In multi-lumen devices (such as double- or triple-lumen catheters and papillotomes), the guidewire port is typically fitted with a removable metal stylet to provide the necessary stiffness during device advancement. Some systems, including short-wire designs, allow the endoscopist immediate control of the guidewire as it exits the accessory channel, ensuring precise and safe positioning under both visual and fluoroscopic guidance.[8]

Modifications such as the Erlangen-type papillotome (with an ultra-short, 5-mm monofilament cutting wire) and devices with scissor-like cutting mechanisms have been developed to offer alternative, sometimes mechanical, methods of tissue incision.[12]

Steerable and rotatable cannulas and papillotomes further improve the angle of approach and overall cannulation success, with studies demonstrating higher success rates and shorter cannulation times compared with standard cannulation catheters.[13] These advanced devices are especially beneficial when encountering distorted or intradiverticular papillae.

Tips and techniques for successful biliary cannulation

Patient selection

The indication of ERCP for diagnostic or therapeutic purposes depends on the skill of the endoscopist carrying out the procedure, the availability of other diagnostic modalities and therapeutic options, and, most importantly, criteria of the patients.[14] As ERCP is an invasive procedure that carries significant risks, including post-ERCP pancreatitis, cholangitis, bleeding, perforation, and anesthesia-related adverse events, it is essential to reserve ERCP for patients with a high likelihood of having common bile duct (CBD) stones. The diagnostic work-up for suspected CBD stones typically involves liver biochemistry and abdominal ultrasound or cross-sectional imaging or endosonography.[15]

Sedation Protocols

Sedation is a crucial aspect of ERCP, as it ensures patient comfort and safety during the procedure. However, sedation for ERCP can be challenging due to the remote location, semi-prone position, and long procedure time.[16]

There are several sedative agents that can be used for ERCP, including propofol, dexmedetomidine, ketamine, and midazolam. The choice of sedative agent depends on various factors, such as the patient's age, medical history, and the anticipated duration of the procedure. Propofol is a short-acting sedative that provides rapid onset and recovery of sedation, but its analgesic properties are limited. Dexmedetomidine is a selective α -2 agonist with sedative and analgesic properties that does not cause respiratory depression. Ketamine is an anesthetic agent that can be used for ERCP to

provide deep sedation and analgesia. Midazolam is a benzodiazepine that is often used in combination with other sedative agents to provide additional anxiolysis.[17]

The optimal sedative agent for ERCP is still being debated. Zhang *et al.* 2024, a recent retrospective study compared the safety and efficacy of four sedative regimens for ERCP: Propofol and Dexmedetomidine (Pro-Dex), Ketamine and Propofol (Keto-Fol), Propofol and Midazolam (Pro-Mid), and Propofol Alone. The study found that the Pro-Dex protocol had several benefits, including faster achievement of desired sedation levels, lower propofol consumption, and shorter recovery times. However, the rates of adverse events associated with ERCP were similar across the four sedation protocols, with no significant differences observed.[17]

Further research is needed to establish the optimal sedation approach for ERCP and to minimize the risk of adverse events. The combination of sedative medicines such as propofol, dexmedetomidine, and ketamine may help to neutralize the adverse effects of each other, resulting in the best and most effective sedation with the least adverse effects for the patient.

1 Basic Cannulation Technique

Despite advancements in endoscopes and accessories, achieving deep cannulation of the desired duct in a native papilla remains one of the most challenging steps in successfully completing an ERCP procedure. No single technique guarantees success, and various factors must be considered to enhance the likelihood of effective cannulation.

The standard ERCP entails two major pillars: Papillary assessment and positioning, and good technique. Regarding papillary assessment and positioning, usually a side-viewing duodenoscope with a channel of 3.7-4.3 mm is used[1]. The duodenoscope is positioned below the papilla to ensure proper visualization of the papilla. If long scope is used, long scope position is required to facilitate better visualization of the major duodenal papilla and to provide a more stable scope position in patients with a very

proximal major papilla. The patient could be shifted into a left lateral decubitus or a supine position to improve the orientation of the duodenoscope.[1]

Key components for successful cannulation include taking the time to study the conformation of the papilla, ensuring proper positioning of the duodenoscope before attempting cannulation, and selecting the appropriate accessory device. When initiating cannulation, it is crucial that the leading edge of the accessory is perpendicular to the ampullary orifice, and that a free "insinuation" of the ampullary orifice is achieved before advancing further.[18] The initial access for biliary cannulation should always be cephalad (uphill). Whether using the wire or catheter tip, the accessory should be positioned perpendicular to the papillary orifice (Figure 2). Before proceeding with cannulation, ensure that the scope position and accessory orientation are optimized. Avoid forcefully engaging the papilla, as this can distort the anatomy and complicate deep cannulation. The first step in cannulation involves gently advancing the tip of the accessory into the ampullary orifice, a maneuver termed "insinuation." Achieving a comfortable "seeding" of the accessory into the orifice is crucial before progressing to deeper cannulation maneuvers. Insinuation can occur with either the catheter tip or the guidewire. Once optimal seating is achieved, options for the next maneuver include injecting a small amount of contrast followed by the advancement of the guidewire or advancing the guidewire alone.[18]

Wire-guided cannulation has been extensively discussed in the literature as a technique to achieve biliary access without contrast injection, which was initially conceived to reduce the risk of post-ERCP pancreatitis. Meta-analyses have concluded that the guidewire technique significantly increases the rate of successful biliary cannulation and is associated with a lower risk of pancreatitis compared to contrast-guided methods (Table 1).[19] The European Society of Gastrointestinal Endoscopy (ESGE) recommends a guidewire-assisted technique for primary common bile duct cannulation to minimize the risk of post-ERCP pancreatitis.[20] Most endoscopists prefer using a straight-tipped guidewire, although some suggest switching to an angled-tipped guidewire if initial attempts fail.[21] A gentle and limited injection of

contrast material can provide a "roadmap" of the intra-ampullary segment, facilitating adjustments to the trajectory of the guidewire or catheter tip under fluoroscopic guidance. ¹ The optimal approach is to use either or both techniques based on the specific circumstances of the case.[18]

No single technique guarantees success in all cases, and it is crucial not to persist obstinately when a particular method is ineffective. If cannulation with the catheter tip is unsuccessful, switching to a guidewire may provide a more precise engagement at the papillary orifice. If the catheter tip enters the pancreatic duct, withdrawing the catheter and restarting from a different angle can improve outcomes. Understanding the anatomy of the papilla and its orientation is essential for predicting the necessary maneuvers for successful cannulation. The presence of a "shar-pei" papilla, characterized by multiple redundant folds and a lack of turgor, requires careful manipulation to achieve deep cannulation. Overall, successful cannulation relies on a combination of careful technique, appropriate device selection, and adaptability to the unique anatomical challenges presented by each patient.[18]

Challenges in cannulation techniques

Selective biliary cannulation is pivotal to ERCP, and difficult biliary cannulation represents a real challenge. According to the European Society of Gastrointestinal Endoscopy, difficult biliary cannulation is defined as (5 attempts - 5 min - 1 pancreatic duct cannulation) where ² five or more cannulation attempts over 5 minutes to achieve cannulation after contacting the papilla and multiple inadvertent pancreatic duct cannulations or opacifications.[22]

Studies have reported various factors leading to difficult cannulation, including papillary anatomy, the experience of the endoscopist, and distal malignant bile obstruction[23-29] Table 2 highlights studies with their respective identified risk factors.

Biliary cannulation during ERCP is significantly influenced by anatomical variations of the major duodenal papilla (Figure 3). The papilla's position, such as its distal

location in the third duodenal portion or proximal orientation near the superior duodenal angle, complicates endoscopic access and visualization. Papillary size further exacerbates challenges: A diminutive papilla may be obscured by mucosal folds or exceed the sphincterotome's tip dimensions, while a large papilla often exhibits instability, hindering secure cannulation. Parallel configurations of the pancreatic and biliary ducts create ambiguity during guidewire advancement, necessitating contrast injection to delineate ductal anatomy. Additionally, periampullary diverticula (PADs) distort papillary orientation, altering the typical 11 o'clock common bile duct orifice position. These structural anomalies demand adaptive techniques, such as mucosal manipulation or precut sphincterotomy, to optimize cannulation success.

Periampullary diverticula (PADs) present unique challenges by obscuring the papilla or displacing its anatomical landmarks (Figure 4). The horizontal orientation of the bile duct in PAD cases negates the need for upward angulation of the sphincterotome, unlike standard anatomy. Techniques such as diverticular rim manipulation with an ERCP catheter or targeted contrast injection may expose the papilla, though these carry risks of perforation or edema. Precut sphincterotomy and pancreatic stent placement are recommended to enhance papillary exposure, achieving cannulation success rates comparable to non-PAD cases. [32–34] However, contrast injection in PADs risks retroperitoneal leakage, emphasizing the need for precision. Despite these hurdles, systematic approaches enable effective navigation of PAD-related anatomical distortions.

Altered anatomy following Billroth II gastrectomy or Roux-en-Y reconstruction necessitates specialized endoscopic strategies. The papilla in these patients is often retrograde to the gastrojejunostomy, requiring balloon-assisted enteroscopy for access. Double-balloon enteroscopy demonstrates superior success rates (95%) compared to spiral or single-balloon methods (83%), attributed to enhanced loop stabilization and scope reach.[35]

Pathological conditions, such as biliary malignancies infiltrating the papilla or duodenum, amplify cannulation challenges by inducing tissue friability, edema, and

hemorrhage. Repeated cannulation attempts exacerbate papillary trauma, leading to swelling and pancreatic opacification, which further obscure visualization. Procedural factors, including inadvertent pancreatic duct cannulation, heighten PEP risk, necessitating prophylactic pancreatic stents. Tumor-related vascular fragility limits the number of feasible cannulation attempts, demanding early escalation to advanced methods. Thus, a balance between persistence and procedural restraint is essential to optimize outcomes in high-risk scenarios.

Advanced techniques in difficult biliary cannulation

Advanced techniques are necessary in difficult biliary cannulations. In a 2016 study by experienced endoscopists, the cannulation success rate with standard techniques was 87%; however, when advanced methods (organized into advanced cannulation techniques and access sphincterotomy; Figure 5) were applied after initial failure, success rates increased to 98.3%.[36]

Access/Precut Sphincterotomy

Access sphincterotomy, also known as precut sphincterotomy, is a technique used to gain access to the biliary tree when standard cannulation attempts fail. This technique involves making an incision at the ampullary orifice using a needle knife, and then extending the incision to access the biliary tree.[18] ESGE recommends using a mixed current rather than pure cut current for sphincterotomy because it decreases the risk of mild bleeding.[20] There are several variations of this technique, including free-hand sphincterotomy, needle-knife sphincterotomy over a pancreatic stent, fistulotomy, and pancreatic sphincterotomy. The choice of technique depends on the personal preference of the endoscopist and the overall health of the pancreas.[18]

Free-Hand Access Sphincterotomy Using a Needle Knife[37]

- Involves an incision at the ampullary orifice, directed cephalad in the 11:00 direction.
- Often performed with a “layering” approach—making a superficial cut first and then deeper incisions until the biliary orifice is identified.

- Generally safe in patients with advanced pancreatic disease (e.g., chronic pancreatitis or pancreatic cancer) but carries a high risk of PEP in patients with a normal pancreas.

Needle-Knife Sphincterotomy Over a Pancreatic Stent

- This technique places a pancreatic stent immediately after failed standard cannulation.[38] The stent:

- Protects pancreatic drainage
- Provides a clear landmark and a stable platform, guiding the incision and preventing an overly deep cut

- ESGE suggests stent placement prior to precutting when pancreatic duct access is easy.[20]

Fistulotomy

It involves making an incision on the dome of the intraduodenal segment of the ampulla rather than starting at the orifice. The cut is gradually deepened (often in a layer-by-layer fashion) until bile is observed, usually in an 11:00 direction.[18] Particularly useful if there is a significant intraduodenal segment of the papilla or in cases with periampullary diverticulum.[39] ESGE recommends needle-knife fistulotomy as the preferred precutting method, with the caveat that it should be performed only by endoscopists whose standard selective biliary cannulation success rate is above 80%. [20] (Figure 6)

Pancreatic Guidewire-Assisted Technique (Double-Wire Technique)

In cases of difficult cannulation with repeated unintentional access to the pancreatic duct, ESGE recommends the “double-wire” technique.[20] This involves achieving deep cannulation of the pancreatic duct with a soft-tipped guidewire that “straightens” the intraampullary angles, making subsequent biliary cannulation easier. A second guidewire (usually loaded in a papillotome or cannula) is then advanced alongside the pancreatic wire toward the biliary system.[18] Studies have shown mixed results; while some report increased success rates in biliary cannulation, caution is advised owing to an increased risk of PEP if used alone.[40] If this technique is applied, prophylactic

small-caliber pancreatic stenting is essential. Note that using a 5 French stent may completely fill the papillary orifice, making cannulation difficult; a 3–4 French stent over an appropriate guidewire (*e.g.*, a 0.025 or 0.018-inch guidewire) may be preferable.[18]

Wire-guided cannulation over a pancreatic stent (WGC-PS) offers an alternative strategy. This method involves placing a short (2–5 cm) 5-Fr pancreatic stent proximal to the ductal genu, followed by WGC above the stent, effectively preventing MPD cannulation. The European Society of Gastrointestinal Endoscopy (ESGE) recommends pancreatic duct stenting prior to WGC or precut sphincterotomy in high-risk scenarios.[31]

Transpancreatic Biliary Sphincterotomy

ESGE advises that when a small papilla makes cannulation difficult and a guidewire accidentally enters the pancreatic duct, experts should consider transpancreatic biliary sphincterotomy. This procedure is used to expose and access the bile duct by cutting through the septum between the pancreatic and biliary ducts, typically using a traction-type papillotome positioned at an 11–12 o'clock direction. Following this technique, prophylactic pancreatic stenting is recommended. Both the sphincterotomy and subsequent stenting should be performed only by endoscopists experienced in ERCP.[20]

Additional Technical Considerations and Altered Anatomy

5 *Endoscopic Papillary Balloon Dilation (EPBD)*

EPBD is suggested as an alternative to endoscopic sphincterotomy for the extraction of CBD stones less than 8 mm, especially in cases with coagulopathy, altered anatomy, or contraindications to sphincterotomy.[20] In patients with Billroth II gastrectomy or complex post-surgical anatomy, ERCP should ideally be performed in specialized referral centers.[41] The use of side-viewing endoscopes (first line) or forward-viewing

endoscopes (as backup) is recommended, along with consideration of EPBD or device-assisted enteroscopy techniques.

⁵ Management in *Periampullary Diverticulum* (PAD)

In patients with PAD and difficult cannulation, pancreatic duct stent placement followed by either precut sphincterotomy (free-hand or over a stent) or needle-knife fistulotomy can be effective. This approach may neutralize the distorted and accentuated angles of the distal bile duct seen in PAD.[20]

⁵ Minor Papilla Cannulation and Post-Surgical Anatomy

For the minor papilla, ESGE suggests wire-guided cannulation (with or without contrast) followed by sphincterotomy using a pull-type sphincterotome or a needle knife over a plastic stent.[20]

Comparative Studies of Advanced Cannulation Techniques

Lee *et al.* 2014 suggested when standard cannulation fails, the decision on which advanced technique to use depends on the scenario and the patient's specific anatomy. If there is no inadvertent entry into the pancreatic duct, early needle-knife techniques—such as fistulotomy—should be considered. However, if three or more unintentional pancreatic duct cannulations occur, the double-wire technique is recommended first. Should the double-wire technique fail, the next step is to perform an access sphincterotomy over a small-caliber pancreatic stent or to consider a transpancreatic biliary sphincterotomy.[42] Facciorusso *et al* 2022 have found that transpancreatic sphincterotomy yields the highest success rate for biliary cannulation, while early needle-knife techniques tend to produce lower rates of post-ERCP pancreatitis (PEP).[43] Overall, the strategy should aim to minimize papillary injury and reduce PEP risk by opting for early intervention and ensuring prophylactic pancreatic stenting when indicated. Ultimately, the choice of technique also depends on the endoscopist's personal preference and the overall health of the pancreas.[18]

Rendezvous methods for biliary cannulation

EUS-guided rendezvous

Biliary duct cannulation can be accomplished *via* percutaneous or endoscopic approaches targeting either the intrahepatic or extrahepatic biliary system, typically using a 19- or 22-gauge fine-needle aspiration (FNA)[44]. Intrahepatic access is frequently achieved through transgastric, transesophageal, or transjejunal routes (particularly in patients with surgically reconstructed anatomy), with the initial puncture directed toward the left hepatic lobe. Extrahepatic access, conversely, is predominantly transduodenal, advancing into the common bile duct (CBD).

Following successful ductal access, therapeutic drainage may be performed through multiple modalities: (1) direct transmural or transluminal drainage; (2) antegrade transpapillary stent placement, or (3) guidewire-facilitated rendezvous techniques. The latter, termed endoscopic ultrasound-guided rendezvous (EUS-RV), involves direct transgastric or transduodenal puncture of the biliary ducts under real-time EUS guidance, followed by antegrade advancement of a guidewire through the needle into the biliary system and across the papilla. This facilitates alignment of the guidewire with a duodenoscope, enabling subsequent conventional endoscopic retrograde cholangiopancreatography (ERCP) and thereby bridging endoscopic and ultrasound-guided procedural strategies. Selective biliary cannulation is then achieved by directing a sphincterotome over the guidewire or in parallel to it, ensuring precise ductal access.

A recent meta-analysis showed that EUS-RV-assisted ERCP was effective and safe in patients who failed biliary cannulation with conventional ERCP[45].

Percutaneous Rendezvous (Perc-RV) Technique

Perc-RV involves percutaneous transhepatic biliary access, typically facilitated by interventional radiology, followed by antegrade guidewire passage through the papilla. This approach demonstrates high efficacy (96% technical success) in anatomically

complex cases, such as Roux-en-Y reconstructions, Billroth II gastrectomy, or infiltrative periampullary tumors, with a low complication rate (2.4%).[46,47]

Iatrogenic complications of ERCP

Failed biliary cannulation² is associated with a higher risk of complications like post-ERCP pancreatitis (PEP), perforation, bleeding, cholangitis, cholecystitis, *etc.* PEP represents the most serious complication associated with ERCP. Studies reported a range between 1% and 30% of post-ERCP pancreatitis[48,49]. Selected studies

The risk of an iatrogenic perforation during ERCP is less than 1%.[70] Perforations can be of all kinds: Esophageal, gastric, or intestinal. These perforations could be classified using the Stapfer classification according to their anatomic location and mechanism as shown in table 4 and Figure 7.

The Stapfer classification guides the perforation management with Stapfer 2 perforations treated medically[71], intraperitoneal perforations (usually in afferent limb in patients with altered anatomy) managed surgically if endoscopic closure cannot be achieved.[72]

Postsphincterotomy bleeding is another ERCP complication. Studies have reported an incidence less than 2%.[72,73] Postsphincterotomy bleeding is associated with bleeding diathesis, active cholangitis, early post-operative anticoagulation administration.[74]

Artificial Intelligence (AI) in ERCP Cannulation:

¹²Recent advancements in artificial intelligence (AI), particularly through convolutional neural networks (CNNs), have shown promise in enhancing the efficiency and safety of ERCP procedures. The potential impact of AI-assisted systems on ERCP has affected efficiency and, safety of ERCP.

AI-assisted systems can significantly improve the efficiency of ERCP procedures. By automating the detection of the ampulla and predicting the difficulty of cannulation, these systems can reduce the time endoscopists spend on these tasks. For instance, the study of Kim et. al.[75] demonstrated that CNN-based models achieved high accuracy

in locating the ampulla, comparable to human experts, which can streamline the decision-making process during procedures. This efficiency is crucial, especially in high-volume clinical settings, where time savings can lead to increased patient throughput and reduced waiting times for procedures.

AI-assisted systems can provide real-time feedback and guidance, helping endoscopists navigate complex cases more effectively. The study of Kim et. al.[75] indicated that the AI system could predict cannulation difficulty, allowing for better preparation and strategy adjustments, ultimately reducing the likelihood of adverse events.

CONCLUSION

Endoscopic retrograde cholangiopancreatography (ERCP) plays a vital role in the management of pancreato-biliary disorders but necessitates technical proficiency. Selective biliary cannulation, a key procedural step, is often complicated by anatomical variations and operator-dependent factors, thereby increasing the risk of post-ERCP pancreatitis (PEP). The implementation of wire-guided cannulation, particularly with prophylactic pancreatic stenting, significantly reduces PEP incidence. In cases of difficult cannulation, salvage techniques such as precut sphincterotomy and rendezvous methods enhance procedural success but require advanced expertise. Artificial intelligence (AI) further enhances ERCP by improving image analysis, optimizing cannulation, and predicting complications, ultimately contributing to procedural success and patient safety. The integration of evolving techniques, AI-driven advancements, adherence to clinical guidelines, and a multidisciplinary approach remains essential for optimizing therapeutic outcomes while minimizing procedural risks.

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SIMILARITY INDEX

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