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Endoscopic Retrograde Cholangiopancreatography-Associated Small Bowel Perforation: A Multidisciplinary Perspective on Clinical Management, Nursing Role, Patient Safety, and Health Informatics

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Abstract

Background: Endoscopic retrograde cholangiopancreatography (ERCP) is an essential minimally invasive procedure for the diagnosis and treatment of pancreaticobiliary disorders. Despite its high therapeutic success, ERCP is associated with potentially serious complications, including post-sphincterotomy bleeding, gastrointestinal perforation, and perforation secondary to biliary stent migration, which may require urgent surgical intervention and multidisciplinary management.

Aim: This narrative review aimed to summarize the current evidence regarding ERCP-related complications requiring surgical intervention, with emphasis on their incidence, diagnosis, classification, clinical presentation, management strategies, and multidisciplinary care.

Methods: A narrative review of published literature was conducted to evaluate the epidemiology, diagnostic approaches, endoscopic management, surgical indications, and outcomes of major ERCP-related complications. Relevant evidence addressing the roles of nursing, pharmacy, health professionals, and health informatics in patient management was also reviewed.

Results: Perforation occurs in approximately 0.4%–1.67% of ERCP procedures, with mortality reaching 8%, while biliary stent migration occurs in approximately 8.5% of cases, and intestinal perforation develops in nearly 1% of migrated stents. Post-sphincterotomy bleeding is primarily managed endoscopically, with surgery reserved for refractory cases. Early diagnosis through clinical assessment, laboratory investigations, and advanced imaging significantly improves outcomes. Multidisciplinary management supported by evidence-based endoscopic, surgical, and informatics-guided interventions enhances patient safety and reduces morbidity and mortality.

Conclusion: Early recognition, prompt intervention, and coordinated multidisciplinary care remain fundamental for improving outcomes in patients experiencing ERCP-related complications. Advances in endoscopic techniques and health informatics continue to reduce the need for surgery while optimizing patient-centered care.

Keywords: Endoscopic retrograde cholangiopancreatography; ERCP; Post-sphincterotomy bleeding; Gastrointestinal perforation; Biliary stent migration; Surgical management; Multidisciplinary care; Health informatics.

Introduction

Endoscopic retrograde cholangiopancreatography (ERCP) has become an essential therapeutic and diagnostic procedure in modern gastroenterology, substantially transforming the management of pancreaticobiliary disorders through minimally invasive intervention. The technique has significantly reduced the need for open surgical procedures in patients with biliary and pancreatic diseases by enabling direct visualization and endoscopic treatment of the biliary and pancreatic ductal systems. ERCP is routinely performed for a wide range of clinical indications, including choledocholithiasis, benign and malignant biliary

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strictures, pancreatic duct disorders, and pancreaticobiliary neoplasms. The procedure has demonstrated considerable success in improving patient outcomes while decreasing postoperative morbidity and shortening hospital stays compared with conventional surgical approaches. Nevertheless, despite its well-established therapeutic benefits and continuous technological advancements, ERCP remains a technically demanding intervention that is associated with a spectrum of procedure-related complications ranging from minor, self-limiting events to severe, life-threatening conditions requiring urgent multidisciplinary management. Overall, adverse events occur in approximately 10% of patients undergoing ERCP and are frequently attributable to procedural complexity, operator-related technical factors, or patient-specific characteristics, including sphincter of Oddi dysfunction, altered gastrointestinal anatomy, congenital anatomical variations, and previous benign or malignant gastroduodenal surgical interventions [1,2].

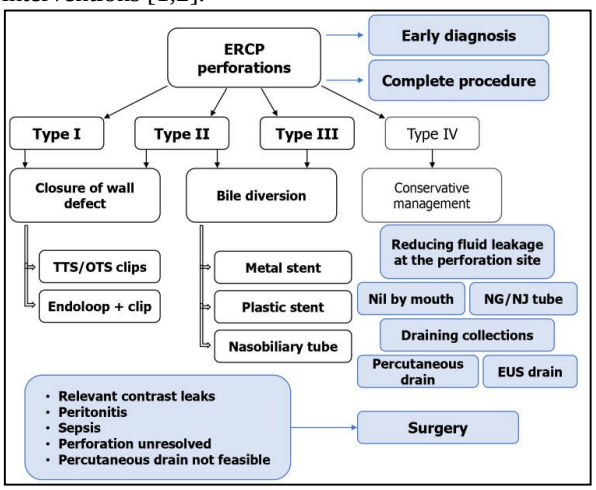

Fig. 1: ERCP Perforation.

The safety profile of ERCP has improved substantially over recent decades through advances in endoscopic equipment, procedural techniques, and peri-procedural patient care. However, complications continue to represent a major challenge because they contribute significantly to patient morbidity, prolonged hospitalization, increased healthcare utilization, and, in severe cases, mortality. Among the recognized adverse events, post-ERCP pancreatitis remains the most frequently encountered complication, with reported incidence rates ranging from 3.5% to 9.7%. Infectious complications, including acute cholangitis and cholecystitis, occur in approximately 1.4% of patients, whereas procedure-related hemorrhage has been reported in 0.3% to 9.6% of cases. Although bleeding is generally manageable through endoscopic hemostatic techniques or conservative measures, the associated mortality rate remains exceptionally low at approximately 0.04%. In a limited proportion of patients, post-sphincterotomy bleeding that fails to respond to endoscopic or interventional radiological management necessitates surgical intervention, accounting for fewer than 10% of all bleeding episodes [3]. Among the various complications associated with ERCP, gastrointestinal perforation represents one of the most infrequent yet clinically devastating adverse events. Although perforation develops in only 0.08% to 0.6% of ERCP procedures, it is associated with substantial morbidity and carries a mortality rate that may reach 0.06% [3,4]. The clinical significance of perforation extends beyond its low incidence because delayed diagnosis or inappropriate management may rapidly result in generalized peritonitis, sepsis, multiorgan dysfunction, and death. ERCP-related perforations may occur at different anatomical locations and are generally classified as either extraluminal or intraluminal injuries. Their clinical presentation varies considerably depending on the mechanism, size, and anatomical site of injury, resulting in substantial heterogeneity in diagnostic evaluation, therapeutic decision-making, and overall patient outcomes [5]. Consequently, timely recognition and accurate characterization of the perforation are fundamental determinants of successful management and favorable prognosis.

In addition to perforation, several uncommon but clinically significant complications have been described in the literature, although their rarity has limited available evidence primarily to isolated case reports and small case series. This limited evidence has contributed to considerable variation in treatment strategies and reported outcomes across different healthcare institutions. One such complication involves the migration of biliary or pancreatic stents from their intended position. Stent migration may lead to ductal obstruction, recurrent infection, vascular injury, or mechanical damage to adjacent organs. In exceptional circumstances, migrated stents can perforate the gastrointestinal tract or surrounding viscera, thereby creating complex clinical situations that frequently require advanced endoscopic retrieval techniques or surgical management. Although visceral perforation secondary to stent migration remains an uncommon occurrence, its potential severity necessitates early recognition and prompt therapeutic intervention [6]. Another exceptionally rare but technically demanding complication is Dormia basket impaction. This event is characterized by entrapment of the stone retrieval basket within the biliary tree or fracture of the basket traction wire during attempts to extract impacted biliary calculi. Basket impaction presents a considerable therapeutic challenge because conventional endoscopic retrieval methods frequently prove unsuccessful. This complication is more commonly encountered in high-volume tertiary referral centers where complex biliary stone disease is managed. Successful treatment often requires innovative endoscopic rescue techniques, percutaneous interventions, or surgical exploration when minimally invasive approaches fail. The rarity and complexity of Dormia basket impaction

underscore the importance of operator expertise and multidisciplinary collaboration in managing these difficult cases [7].

Among all complications encountered during ERCP, severe bleeding, gastrointestinal perforation, perforation associated with migrated stents, and Dormia basket impaction represent the most clinically challenging scenarios. These complications frequently require rapid clinical assessment, advanced diagnostic imaging, and coordinated multidisciplinary intervention involving gastroenterologists, surgeons, radiologists, anesthesiologists, and critical care specialists. Surgical management remains an essential component of treatment for selected patients, particularly when conservative or endoscopic interventions are unsuccessful or when extensive tissue injury, generalized peritonitis, or hemodynamic instability is present [8]. Failure to promptly diagnose and appropriately manage these complications may result in rapid clinical deterioration, prolonged intensive care admission, increased healthcare expenditures, delayed functional recovery, and significant long-term morbidity. Continuous innovation in endoscopic technology, high-definition imaging systems, accessory devices, and procedural techniques has substantially enhanced the safety and therapeutic effectiveness of ERCP. Improvements in patient selection, risk stratification, prophylactic measures, and operator training have also contributed to reducing complication rates. Nevertheless, procedure-related adverse events remain an unavoidable aspect of ERCP practice because of the inherent technical complexity of the intervention and the diversity of underlying pancreaticobiliary diseases. Furthermore, the optimal management of severe ERCP-related complications, particularly those requiring operative treatment, continues to be debated owing to the absence of universally accepted treatment algorithms and the considerable variability in clinical presentation, patient characteristics, and institutional expertise.

DIAGNOSIS AND EARLY RECOGNITION

The timely diagnosis and early recognition of complications following endoscopic retrograde cholangiopancreatography (ERCP) are fundamental to minimizing morbidity, preventing disease progression, and improving patient outcomes. Because ERCP-related complications can range from mild, self-limiting conditions to rapidly progressive, life-threatening emergencies, clinicians must maintain a high index of suspicion during the immediate post-procedural period and throughout subsequent clinical follow-up. Early identification relies on a comprehensive diagnostic approach that integrates careful clinical assessment, targeted laboratory investigations, and appropriate imaging modalities. This multidisciplinary strategy facilitates accurate diagnosis, guides therapeutic decision-making, and enables prompt intervention before irreversible complications develop [3]. Clinical evaluation represents the cornerstone of the diagnostic process and should begin immediately after the procedure. A detailed assessment of the patient's symptoms, physical examination findings, procedural history, and individual risk factors is essential for identifying early signs of adverse events. Symptoms such as persistent or worsening abdominal pain, abdominal distension, fever, nausea, vomiting, hypotension, tachycardia, or signs of peritoneal irritation should prompt immediate investigation for potential complications, including pancreatitis, perforation, hemorrhage, or biliary infection. Continuous monitoring of vital signs and serial physical examinations are particularly important because some complications may initially present with subtle clinical manifestations before progressing to more severe disease. Early clinical deterioration, even in the absence of definitive laboratory or radiological abnormalities, should not be underestimated, particularly in high-risk patients or following technically difficult ERCP procedures [3].

Laboratory investigations provide valuable objective information that complements clinical assessment and assists in differentiating among the various ERCP-related complications. Measurement of serum amylase and lipase concentrations remains the primary biochemical approach for diagnosing post-ERCP pancreatitis, particularly when elevated enzyme levels are accompanied by characteristic abdominal pain. Complete blood count analysis is equally important for identifying leukocytosis suggestive of infection or systemic inflammation, while reductions in hemoglobin or hematocrit may indicate ongoing gastrointestinal or retroperitoneal bleeding. Inflammatory biomarkers, including C-reactive protein and erythrocyte sedimentation rate, contribute to evaluating the extent of inflammatory response and may assist in monitoring disease severity, especially in patients with suspected perforation or intra-abdominal infection. Furthermore, liver function tests, including serum bilirubin, alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, and gamma-glutamyl transferase, are indispensable for assessing biliary obstruction, cholestasis, bile duct injury, or acute cholangitis. Serial laboratory measurements are often more informative than isolated values because dynamic changes may reflect disease progression or therapeutic response [1,3]. Diagnostic imaging plays a pivotal role in confirming clinical suspicion, defining the extent of injury, and guiding subsequent management. Abdominal ultrasonography is frequently employed as the initial imaging modality because of its wide availability, non-invasive nature, and ability to detect biliary duct dilatation, gallbladder pathology, fluid collections, or gross anatomical abnormalities. Although ultrasonography provides valuable preliminary information, its diagnostic

accuracy may be limited by patient body habitus, bowel gas, and operator dependency, particularly when evaluating retroperitoneal structures or subtle perforations.

Contrast-enhanced computed tomography (CT) has become the imaging modality of choice for comprehensive evaluation of suspected ERCP-related complications. CT provides excellent visualization of abdominal and retroperitoneal anatomy and is highly effective in identifying pancreatic inflammation, peripancreatic fluid collections, free intraperitoneal or retroperitoneal air, active hemorrhage, abscess formation, bile leakage, and migrated biliary or pancreatic stents. In addition to confirming the diagnosis, CT imaging contributes significantly to determining the severity and anatomical extent of complications, thereby facilitating appropriate selection between conservative, endoscopic, radiological, or surgical management strategies [1,4]. Magnetic resonance cholangiopancreatography (MRCP) offers an additional non-invasive imaging modality with excellent visualization of the biliary and pancreatic ductal systems. Owing to its superior soft tissue contrast and high spatial resolution, MRCP is particularly valuable in patients with suspected biliary strictures, ductal obstruction, bile leakage, or complex pancreaticobiliary abnormalities that may not be fully characterized using other imaging techniques. The ability of MRCP to delineate ductal anatomy without ionizing radiation or invasive instrumentation further enhances its clinical utility in selected patients, particularly when repeat endoscopic procedures are considered undesirable or technically challenging [3]. The integration of clinical findings, laboratory parameters, and advanced imaging techniques constitutes the foundation of an effective diagnostic strategy for ERCP-related complications. This comprehensive approach not only facilitates early recognition of potentially life-threatening adverse events but also enables timely implementation of appropriate therapeutic interventions. Prompt diagnosis reduces the likelihood of disease progression, decreases the need for extensive surgical procedures, shortens hospital stay, and ultimately improves both short-term clinical outcomes and long-term patient prognosis. Consequently, maintaining vigilance and adopting a systematic diagnostic pathway remain essential components of high-quality care for patients undergoing ERCP.

POST-SPHINCTEROTOMY BLEEDING (PSB)

Post-sphincterotomy bleeding (PSB) is a recognized complication of endoscopic retrograde cholangiopancreatography (ERCP) that ranges from minor, self-limiting hemorrhage to severe bleeding requiring urgent therapeutic intervention. Bleeding may occur immediately during the endoscopic procedure or develop several hours to days later as delayed hemorrhage. The timing, severity, and underlying mechanism of bleeding influence both the clinical presentation and the selection of appropriate management strategies. Although advances in therapeutic endoscopy have substantially reduced the need for operative intervention, PSB remains a clinically significant complication because uncontrolled hemorrhage may result in hemodynamic instability, blood transfusion requirements, prolonged hospitalization, and increased morbidity. Consequently, rapid diagnosis and prompt treatment are essential to prevent clinical deterioration and improve patient outcomes. Contemporary management emphasizes a structured, stepwise approach that prioritizes minimally invasive techniques while reserving surgical intervention for patients in whom conservative, endoscopic, and radiological therapies have failed [9]. The initial management of PSB focuses on achieving rapid hemostasis while minimizing additional tissue injury. Early endoscopic intervention remains the cornerstone of treatment, with balloon tamponade frequently serving as the first therapeutic maneuver to provide temporary mechanical compression of the bleeding site. Following balloon tamponade, local injection of diluted epinephrine at a concentration of 1:10000 is commonly performed to induce vasoconstriction and reduce active bleeding. This combination of mechanical compression and pharmacological vasoconstriction has demonstrated high effectiveness in controlling mild to moderate hemorrhage and is widely considered the first-line therapeutic approach in clinical practice [10]. Careful endoscopic visualization during these procedures is essential to accurately identify the bleeding source and assess the effectiveness of the intervention.

When epinephrine injection alone fails to establish adequate hemostasis, additional endoscopic modalities become necessary. Thermal coagulation techniques, including heater probe therapy and monopolar electrocautery, provide controlled coagulation of bleeding vessels and are commonly employed as second-line treatment options. These techniques effectively seal injured vessels through localized thermal injury while preserving surrounding tissue integrity. If bleeding persists despite pharmacological and thermal therapy, endoscopic clipping offers another valuable therapeutic alternative. Mechanical clips directly approximate the bleeding vessel or injured mucosa, providing immediate hemostasis without introducing additional thermal damage. The availability of multiple complementary endoscopic techniques has significantly improved the overall success rate of non-surgical management for PSB and has substantially decreased the frequency with which surgical treatment is required [11-14]. In patients experiencing severe, persistent, or recurrent hemorrhage despite conventional endoscopic therapy, fully covered self-expanding metal stents have emerged as an effective rescue treatment and, in selected cases, may even serve as primary therapy. These stents achieve hemostasis by exerting continuous radial compression over the

sphincterotomy site, thereby controlling active bleeding while maintaining biliary drainage. Their use has expanded considerably owing to favorable clinical outcomes and reduced need for emergency surgery. Nevertheless, these devices require careful post-procedural surveillance because prolonged placement may result in complications such as stent migration, biliary obstruction, or in-stent occlusion. Timely removal following successful hemostasis is therefore essential to minimize secondary adverse events [15,16].

Additional hemostatic agents have further expanded the therapeutic options available for refractory PSB. Topical fibrin glue and hemostatic powder have demonstrated encouraging clinical effectiveness in achieving bleeding control when standard endoscopic interventions prove unsuccessful. These agents are particularly valuable in situations where active hemorrhage obscures visualization of the bleeding source, making targeted endoscopic therapy technically difficult. Hemostatic powder can rapidly coat large mucosal surfaces and promote clot formation, whereas fibrin glue provides biological sealing of injured tissue. Their ease of application and favorable safety profile make these therapies important adjunctive options in managing complex or massive hemorrhage [17,18]. When endoscopic techniques fail to control ongoing bleeding, angiographic embolization represents the preferred minimally invasive alternative before considering operative intervention. Selective catheter-directed embolization enables precise occlusion of the responsible arterial branch while preserving blood flow to surrounding tissues. This approach has demonstrated high rates of technical and clinical success and has become an integral component of the multidisciplinary management of refractory PSB. Despite its effectiveness, angiographic embolization is associated with significant mortality in critically ill patients, particularly those with underlying coagulopathy, advanced comorbidities, or persistent hemodynamic instability. Therefore, patient selection and close collaboration between gastroenterologists, interventional radiologists, surgeons, and critical care specialists are essential for optimizing outcomes [19].

Open surgical intervention has become increasingly uncommon owing to the success of advanced endoscopic and interventional radiological techniques. Nevertheless, surgery remains an indispensable therapeutic option when all less invasive measures have failed or when uncontrolled hemorrhage threatens patient survival. Current evidence regarding the surgical management of PSB remains limited because of the rarity of cases requiring operative treatment. Available literature suggests that open surgical ligation of the bleeding vessel should be reserved as the final therapeutic option following unsuccessful angiographic embolization [5,19]. A case series published by Dunne et al. [19] described the interventional radiological management of eleven patients with PSB, among whom one patient ultimately required surgical exploration after repeated embolization attempts failed to control hemorrhage originating from the inferior pancreaticoduodenal artery. Anatomically, the gastroduodenal artery represents the most frequent source of significant post-sphincterotomy bleeding, followed by the superior and inferior pancreaticoduodenal arteries. Surgical treatment typically involves direct ligation of the responsible vessel, most commonly the gastroduodenal artery, and is estimated to be necessary in approximately 10% of patients after failed embolization therapy [5,19,20]. Although rarely performed, prompt surgical intervention remains lifesaving in carefully selected patients and continues to play a critical role within the comprehensive multidisciplinary management of severe ERCP-related hemorrhagic complications.

PERFORATIONS

Perforation is one of the most serious and potentially life-threatening complications associated with endoscopic retrograde cholangiopancreatography (ERCP). Although its reported incidence is relatively low, ranging from approximately 0.4% to 1.67% of all ERCP procedures, the clinical consequences can be profound, with mortality rates reaching 8% in severe cases [1,4]. The rarity of this complication should not diminish its clinical importance because delayed diagnosis or inappropriate management can rapidly lead to generalized peritonitis, retroperitoneal infection, septic shock, multiorgan failure, and death. Advances in endoscopic technology, improved imaging techniques, and increasing procedural expertise have significantly enhanced the early recognition and minimally invasive management of ERCP-related perforations. Nevertheless, surgery remains an essential therapeutic option for carefully selected patients, particularly when conservative or endoscopic interventions fail or when extensive tissue injury is present [4,21,22]. The management of ERCP-related perforations is largely determined by the anatomical location, mechanism of injury, extent of tissue damage, and the patient's overall clinical condition. To facilitate standardized diagnosis and treatment planning, several classification systems have been proposed. Among the earliest was the classification introduced by Howard et al. [23], which categorized perforations according to their anatomical site and underlying mechanism. Subsequently, Stapfer et al. [24] developed a more comprehensive classification that has become the most widely accepted framework in clinical practice. Stapfer's classification divides ERCP-related perforations into four distinct categories, each associated with different therapeutic strategies and prognostic implications. Type I perforations involve large defects of the lateral

or medial duodenal wall and generally require immediate closure of the perforation. Type II injuries occur in the periampullary region and usually require both closure of the defect and effective biliary diversion. Type III perforations result primarily from instrumentation of the bile duct and are generally managed through biliary drainage without extensive surgical repair. Type IV lesions are characterized by the presence of retroperitoneal air without a true perforation and are typically managed conservatively. This classification has become an important clinical tool because it provides a structured approach for selecting the most appropriate therapeutic strategy according to the severity and anatomical characteristics of the injury [24].

The introduction of advanced therapeutic endoscopy has substantially reduced the need for operative management of ERCP-related perforations. Endoscopic closure techniques are now considered first-line treatment for many patients diagnosed early after injury. Through-the-scope clips can be deployed using either a duodenoscope or a forward-viewing endoscope equipped with a distal attachment cap, allowing direct approximation of small perforation margins. Larger defects may require multiple through-the-scope clips, loop-and-clip techniques, or over-the-scope clipping systems that provide stronger tissue compression and more durable closure. Early endoscopic intervention has been associated with rapid sealing of the perforation, earlier resumption of oral nutrition, reduced hospitalization, and lower rates of postoperative complications compared with delayed treatment [21,22]. For patients with Stapfer type II and type III perforations, successful management frequently depends not only on closure of the injury but also on adequate diversion of biliary secretions away from the perforation site. Endoscopic biliary stenting effectively reduces intraductal pressure, minimizes bile leakage, and promotes tissue healing. Fully covered self-expandable metal stents are generally preferred because they provide more effective biliary decompression, superior pain control, shorter hospital stays, and lower rates of retroperitoneal abscess formation compared with alternative stent designs. Supportive medical therapy also represents an essential component of conservative management. Patients are typically maintained on nil per os status to minimize gastrointestinal secretions, while nasogastric or nasojejunal decompression reduces intraluminal pressure and limits contamination at the perforation site. Proton pump inhibitors are administered to decrease gastric acid production and reduce digestive fluid exposure to injured tissues. When retroperitoneal or intra-abdominal fluid collections develop, image-guided percutaneous drainage or endoscopic ultrasound-guided internal drainage can effectively control infection and promote recovery without requiring surgical exploration [21,22].

Despite significant advances in minimally invasive therapy, conservative management is not universally successful. Surgical intervention remains mandatory in patients with uncontrolled leakage, persistent fluid collections despite adequate drainage, generalized peritonitis, progressive sepsis, or hemodynamic instability. The choice of surgical procedure depends on several factors, including the anatomical location and size of the perforation, the interval between injury and diagnosis, the patient's physiological status, and the presence of associated biliary or pancreatic pathology. Surgical options include primary closure of the perforation, extensive abdominal lavage, placement of surgical or percutaneous drains, and reconstructive procedures such as gastrojejunostomy when extensive tissue damage prevents primary repair. Approximately 5% of patients require immediate operative management following diagnosis, whereas an additional 11% ultimately undergo salvage surgery after unsuccessful conservative or endoscopic treatment [5]. The timing of surgical intervention has a major influence on clinical outcomes. Dahale et al. [25] reported that Stapfer type I perforations require immediate operative treatment in approximately 0.04% of ERCP procedures. A systematic review published in 2017 demonstrated that delaying surgery beyond 24 hours after ERCP for type I injuries is associated with substantially more complex operative procedures, increased postoperative complications, and significantly higher mortality rates [1]. Similarly, Samara et al. [8] emphasized that early evaluation by experienced endoscopists and hepatopancreatobiliary surgeons is essential for determining the optimal treatment strategy. Prompt multidisciplinary assessment facilitates appropriate patient selection for conservative management while ensuring that patients requiring surgery undergo timely intervention before irreversible physiological deterioration occurs. Failure of conservative treatment in type I perforations is associated with an exceptionally high postoperative mortality approaching 75%, highlighting the importance of early decision-making [8].

Management strategies differ considerably according to perforation type. Patients with type II perforations diagnosed either during ERCP or shortly thereafter who remain clinically stable, exhibit only mild lumbar pain, and demonstrate little or no contrast extravasation can usually be managed successfully using endoscopic clipping, biliary stenting, and comprehensive medical therapy. Persistent retroperitoneal fluid collections may require additional image-guided percutaneous drainage or endoscopic ultrasound-guided drainage to prevent abscess formation. However, surgery becomes necessary when conservative treatment fails or when patients develop severe sepsis or progressive clinical deterioration because delayed operative intervention is associated with increased mortality [5,23]. In patients with previous partial gastrectomy and gastrointestinal

reconstruction, a posterior laparotomy approach may provide superior access for drainage while minimizing contamination and reducing the risk of injury to reconstructed jejunal segments. Furthermore, perforation involving the afferent loop during duodenoscope insertion represents a particularly serious complication that generally necessitates immediate surgical repair [26]. Stapfer type III perforations generally have the most favorable prognosis, with conservative management achieving successful outcomes in approximately 95% of patients. Endoscopic biliary drainage, antibiotic therapy, bowel rest, and careful clinical observation are usually sufficient for complete recovery. Nevertheless, operative treatment may still be required when persistent intra-abdominal or retroperitoneal collections develop, retained biliary calculi cannot be removed endoscopically, or retrieval devices become irreversibly impacted within the biliary tree. Reported postoperative mortality following failed conservative treatment varies markedly according to perforation type, reaching approximately 75% for type I injuries, 22% for type II injuries, and 0% for type III perforations. These substantial differences emphasize the importance of accurate classification, early diagnosis, individualized treatment planning, and timely multidisciplinary intervention to optimize survival and reduce the long-term consequences of ERCP-related perforations [5].

PERFORATION DUE TO STENT MIGRATION

Biliary stent placement is an integral component of therapeutic endoscopic retrograde cholangiopancreatography (ERCP) and is widely performed for the management of benign and malignant biliary obstruction, postoperative bile leaks, biliary strictures, and pancreaticobiliary disorders. The use of biliary stents has substantially improved biliary drainage, reduced the need for surgical intervention, and enhanced clinical outcomes in a broad spectrum of hepatopancreatobiliary diseases. Despite these benefits, biliary stenting is associated with several procedure-related complications, among which stent migration represents one of the most clinically significant. Stent migration may occur either proximally into the biliary tree or distally into the gastrointestinal tract, with distal migration being considerably more common. Although most migrated stents traverse the gastrointestinal tract without causing injury and are spontaneously expelled, a small proportion become impacted within the intestinal lumen, resulting in serious complications including bowel obstruction, fistula formation, abscess development, hemorrhage, and gastrointestinal perforation. These events, although uncommon, may require urgent intervention and are associated with substantial morbidity and mortality [27]. Following endoscopic biliary stent placement, stent dislocation and migration have been reported in approximately 8.5% of patients [27]. Intestinal perforation resulting from migrated biliary stents occurs in approximately 1% of migration cases and represents one of the most severe delayed complications of biliary stenting [28]. Despite its clinical importance, perforation secondary to stent migration has received relatively limited attention in contemporary clinical guidelines, largely because of its rarity and the limited availability of high-quality evidence. Consequently, treatment recommendations are primarily derived from individual case reports, small retrospective studies, and institutional experience. This lack of standardized management algorithms contributes to considerable variability in clinical practice and emphasizes the importance of individualized treatment based on patient characteristics and the severity of the complication.

The type of biliary stent significantly influences the likelihood of migration and subsequent perforation. Plastic biliary stents are associated with a substantially greater risk of distal migration than self-expandable metal stents because of their smaller diameter, smoother surface, and reduced anchoring capacity within the biliary system. As a result, plastic stents account for the majority of reported cases of migration-induced intestinal perforation. Mortality associated with this complication has been reported to reach 10.3%, highlighting the potentially life-threatening nature of this adverse event [6]. Anatomically, perforation most frequently occurs within the duodenum because of its close proximity to the biliary tract and the relatively fixed position of this intestinal segment. Other reported sites include the large intestine, small intestine, and, less commonly, the biliary duct itself. Because perforation often results in contamination of surrounding tissues and progression to localized or generalized infection, surgical management remains the preferred treatment strategy in many patients [6]. The pathophysiological mechanisms underlying stent-induced perforation are influenced by both patient-related and device-related factors. Chronic mechanical pressure exerted by the migrated stent against the intestinal wall may gradually lead to mucosal erosion, ischemia, tissue necrosis, and eventual full-thickness perforation. Factors such as advanced age, diverticular disease, postoperative adhesions, intestinal strictures, previous abdominal surgery, altered gastrointestinal anatomy, and prolonged stent retention increase the susceptibility to perforation. In many patients, migration occurs silently without immediate symptoms, allowing the stent to remain within the intestinal lumen for prolonged periods before complications become clinically apparent. This delayed presentation contributes to diagnostic challenges and may postpone definitive treatment.

Retroperitoneal perforation resulting from migrated biliary stents occurs more frequently than

intraperitoneal perforation because of the anatomical relationship between the duodenum and the retroperitoneal space. However, intraperitoneal perforations generally produce more severe clinical manifestations because of widespread contamination of the peritoneal cavity and rapid progression to generalized peritonitis. In most patients, perforation develops several days or even weeks after stent placement, reflecting the gradual process of tissue erosion. Nevertheless, isolated reports have documented perforation occurring within the first 24 hours following stent insertion, indicating that early complications may also occur under specific circumstances [29]. In certain cases, migrated stents remain lodged within the intestine for prolonged periods, eventually causing localized inflammation and secondary complications such as pelvic abscess formation or chronic fistulous communication with adjacent organs [30]. The management of perforation secondary to biliary stent migration requires careful clinical assessment and individualized therapeutic planning. Treatment decisions depend on multiple factors, including the patient's hemodynamic stability, overall physiological condition, anatomical location of the perforation, extent of intestinal injury, presence of intraperitoneal or retroperitoneal contamination, size of associated fluid collections, and the availability of advanced endoscopic, interventional radiological, and surgical expertise. Patients who remain clinically stable and exhibit small, well-contained perforations without evidence of generalized peritonitis or extensive fluid collections may be suitable candidates for conservative or endoscopic management. Conservative treatment typically includes bowel rest, intravenous fluid resuscitation, broad-spectrum antimicrobial therapy, nutritional support, and close clinical monitoring. Endoscopic retrieval of the migrated stent, followed by closure of the perforation using endoscopic clips or other closure devices, may be successfully performed in carefully selected patients with localized injuries [31,32].

Surgical intervention becomes mandatory when patients develop generalized peritonitis, uncontrolled sepsis, hemodynamic instability, extensive retroperitoneal fluid collections, or failure of conservative and endoscopic treatment. Additional indications include complications such as colovesical fistulas, colocutaneous fistulas, persistent abscess formation, bowel obstruction, or extensive tissue necrosis resulting from prolonged stent impaction [31,32]. Surgical management aims to remove the migrated stent, repair the perforated bowel segment, eliminate intra-abdominal contamination, and control ongoing infection. The specific operative procedure depends on the location and severity of the injury and may include primary bowel repair, segmental intestinal resection with primary anastomosis, diversion procedures such as temporary colostomy, or extensive abdominal drainage in patients with diffuse peritonitis. Clinical evidence indicates that most patients with stent migration-induced perforation ultimately require operative treatment. A study published in 2018 demonstrated that surgical intervention resulted in favorable postoperative outcomes in the majority of affected patients, with successful management of associated peritonitis and intra-abdominal abscesses and generally uncomplicated postoperative recovery [33]. Immediate surgical intervention, including primary intestinal repair, bowel resection with anastomosis, or colostomy when indicated, continues to represent the standard treatment for patients with extensive contamination or severe perforation. Conversely, endoscopic management may be considered when perforations remain localized or covered and when no clinical or radiological evidence of generalized peritonitis is present. Endoscopic retrieval is also recommended when distally migrated biliary stents are incidentally identified during routine surveillance in patients considered to be at increased risk for intestinal perforation, thereby preventing progression to more severe complications [34].

Although intestinal perforation resulting from biliary stent migration rarely necessitates highly complex reconstructive surgery, delayed diagnosis substantially increases the risk of morbidity and mortality [35]. Consequently, appropriate follow-up protocols following biliary stent placement are essential to ensure timely identification of migrated stents before serious complications develop. Regular clinical assessment, appropriate radiological surveillance when indicated, and effective communication with patients regarding the importance of scheduled stent removal or replacement are fundamental aspects of preventive care. Particular attention should be directed toward elderly individuals and patients with altered gastrointestinal anatomy because these populations demonstrate an increased risk of complications related to prolonged stent retention. Comprehensive follow-up strategies not only reduce the incidence of perforation but also minimize other stent-related complications, including malposition, obstruction, rupture, migration, and infection, thereby improving long-term patient safety and clinical outcomes [36].

Role of Nursing, Pharmacists, Health Professionals, and Informatics:

The successful prevention, early recognition, and management of endoscopic retrograde cholangiopancreatography (ERCP)-related complications depend on effective multidisciplinary collaboration involving nurses, pharmacists, physicians, allied health professionals, and health informatics specialists. Coordinated teamwork improves patient safety, facilitates timely clinical decision-making, reduces adverse outcomes, and enhances the overall quality of care throughout the peri-procedural period. Nurses play a central role in patient assessment, preparation, monitoring, and postoperative care. They are responsible for

identifying early signs of complications such as abdominal pain, fever, bleeding, hypotension, and altered vital signs, enabling prompt communication with the multidisciplinary team. Nursing responsibilities also include patient education regarding pre-procedural preparation, medication adherence, dietary restrictions, post-discharge warning signs, and follow-up appointments. Continuous clinical observation and accurate documentation contribute significantly to early diagnosis and improved patient outcomes. Pharmacists contribute by optimizing medication therapy before, during, and after ERCP. Their responsibilities include reviewing medication histories, identifying potential drug interactions, managing anticoagulants and antiplatelet agents, recommending appropriate antimicrobial prophylaxis, optimizing analgesic and antiemetic therapy, and monitoring adverse drug reactions. Pharmacists also support antimicrobial stewardship and ensure appropriate dosing adjustments in patients with hepatic or renal impairment. Physicians, radiologists, anesthesiologists, endoscopists, surgeons, and other healthcare professionals collaborate to establish accurate diagnoses, perform therapeutic interventions, and manage complications through evidence-based multidisciplinary care. Effective communication among healthcare providers facilitates rapid clinical responses, appropriate referral, and individualized treatment planning. Health informatics further strengthens patient safety by integrating electronic health records, computerized clinical decision support systems, and standardized documentation tools. These technologies improve communication, facilitate risk assessment, generate automated clinical alerts, support medication safety, monitor procedural outcomes, and enable quality improvement initiatives. Collectively, multidisciplinary collaboration supported by health informatics enhances clinical efficiency, promotes evidence-based practice, and improves patient-centered outcomes following ERCP.

Conclusion:

Endoscopic retrograde cholangiopancreatography remains an indispensable therapeutic procedure for the management of pancreaticobiliary diseases despite its association with potentially life-threatening complications. Post-sphincterotomy bleeding, gastrointestinal perforation, and perforation resulting from biliary stent migration require rapid recognition, accurate diagnosis, and timely intervention to minimize morbidity and mortality. Recent advances in endoscopic technologies, imaging modalities, and minimally invasive therapeutic techniques have significantly improved the management of these complications and reduced the necessity for surgical intervention. Nevertheless, surgery continues to play a critical role in patients with extensive tissue injury, uncontrolled hemorrhage, generalized peritonitis, or failure of conservative and endoscopic treatment. Successful management depends on individualized treatment strategies guided by clinical presentation, perforation classification, and patient condition. Equally important is the contribution of multidisciplinary collaboration among endoscopists, surgeons, nurses, pharmacists, radiologists, and health informatics specialists in ensuring comprehensive, evidence-based care. Continued improvements in procedural techniques, standardized management protocols, and integrated healthcare technologies will further enhance patient safety, reduce complication-related mortality, and improve both short-term and long-term clinical outcomes following ERCP.

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