Post-ERCP perforation

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INTRODUCTION

Perforation is one of the most serious complications of endoscopic retrograde cholangiopancreatography (ERCP). This topic will focus on the risk factors, diagnosis, and treatment of post-ERCP perforation. An overview of ERCP and detailed discussions of other complications are presented separately:

- (See "Overview of endoscopic retrograde cholangiopancreatography (ERCP) in adults".)
- (See "Post-endoscopic retrograde cholangiopancreatography (ERCP) pancreatitis".)
- (See "Post-endoscopic retrograde cholangiopancreatography (ERCP) bleeding".)

CLASSIFICATION

Four types of perforation complicating ERCP have been recognized [1,2]. The Stapfer classification is most commonly used and is based on the mechanism, anatomical location, and severity of the injury that may predict the need for surgical intervention (figure 1) [2]:

- Type I: Free duodenal wall perforation
- Type II: Retroperitoneal duodenal perforation secondary to periampullary injury
- Type III: Perforation of the pancreatic or bile duct
- Type IV: Retroperitoneal air alone

Of these, type II retroperitoneal duodenal perforations are the most common. In a case series of 44 post-ERCP perforations, 30 (68 percent) were retroperitoneal duodenal perforations, which usually occur as a result of a sphincterotomy or large balloon dilation that extends beyond the intramural portion of bile duct [3]. Perforation of the pancreatic or bile duct usually occurs following dilation of strictures, forceful cannulation, guidewire manipulation, stent migration, or difficult stone extraction [4-12]. Liver and pancreatic parenchymal perforation by the guidewire during ERCP is an under-appreciated complication, and subcapsular liver hematoma and subcapsular biloma can occur in this context [13,14]. (See "Uncommon complications of endoscopic retrograde cholangiopancreatography (ERCP)".)

Type I free perforation of the duodenum (ie, lateral or medial wall, remote from the ampulla) or the jejunum is caused by the endoscope, is rare, and usually occurs in patients with a stricture or altered anatomy, such as Billroth II gastrectomy [15-18]. (See "Endoscopic retrograde cholangiopancreatography (ERCP) after Billroth II reconstruction" and "ERCP in patients with Roux-en-Y anatomy".)

In a single-center series, 79 post-ERCP perforations were diagnosed: seven perforations were type I, 54 were type II, nine were type III, six were type IV, and three were hypopharyngeal or esophageal [18]. While most patients with Type II perforations were medically managed, four patients from this group (7 percent) required surgical intervention.

Gastric and esophageal perforation [4,19,20] and pneumomediastinum without evidence of perforation [21] have also been described after ERCP and sphincterotomy and in patients with altered anatomy, such as an esophageal diverticulum or stricture. Intestinal perforation related to biliary stents is uncommon. (See "Endoscopic stenting for malignant biliary obstruction", section on 'Stent-related'.)

INCIDENCE

Retroduodenal perforation was reported in 0.5 to 2.1 percent of patients who had ERCP with sphincterotomy in older series [22]. The incidence of perforation has appeared to decrease to less than 0.5 percent, probably because of improvement in instruments, accessories, and experience and skill of endoscopists [23]. However, severe and fatal cases continue to occur [24,25]. In a summary of 21 prospective studies involving 16,855 patients undergoing ERCP, procedure-related perforation was reported in 101 patients (0.60 percent), with 10 deaths (0.06 percent) [26].

Multiple observational studies have described perforation rates following ERCP [1-4,11,12,27-53]. According to these series including nearly 210,000 ERCPs, 830 procedures were complicated by perforation (approximately 0.4 percent), with a mortality rate among patients with perforation of approximately 7 to 8 percent. Type I perforations accounted for 25 percent of perforations, type II for 46 percent, type III for 22 percent, and type IV for 3 percent [50]. (See 'Classification' above.)

RISK FACTORS

A number of patient- and procedure-related risk factors for perforation have been identified in individual reports and in large series. A difficulty with interpreting the risk factors identified in these reports is that many of the studies combined free bowel wall perforation at a site remote from the papilla (endoscope-related) and periampullary retroperitoneal perforation (sphincterotomy-related). The mechanisms leading to the different types of perforations vary substantially. Furthermore, the absolute number of patients studied is small, reflecting the infrequent occurrence of these complications.

All perforations — The following risk factors for free abdominal or retroperitoneal perforation have been identified [54,55]:

- Patient-related risk factors – Surgically altered anatomy, female sex, older age, dilated common bile duct, and the presence of a papillary lesion. Sphincter of Oddi dysfunction was a risk factor for perforation in older studies, but ERCP is not typically performed for this indication.

- Procedure-related risk factors – Sphincterotomy, use of precut needle-knife methods for bile duct access, endoscopic papillary large-balloon dilatation, biliary stricture dilation, difficult cannulation, intramural injection of contrast material, longer duration of the procedure, and less experienced endoscopists.

Bowel wall perforation — The risk of bowel wall perforation is increased in patients who have stenosis in the upper gastrointestinal tract, and in patients with altered anatomy, such as gastrectomy, pancreaticoduodenectomy, situs inversus, or periampullary diverticula [15,16,18,28,56,57]. Particular caution is required with the use of a side-viewing duodenoscope (the endoscope typically used for ERCP) in patients with a Billroth II gastrectomy [56,58]. (See "Endoscopic retrograde cholangiopancreatography (ERCP) after Billroth II reconstruction".)

Retroperitoneal perforation — The risk of retroperitoneal perforation is increased with precut sphincterotomy and larger sphincterotomies, particularly those that are created outside of the

usually recommended landmarks (11 to 1 o'clock) [59-62]. In one report, 7 of 13 sphincterotomy perforations were related to precutting [4]. (See "Precut (access) papillotomy".)

Use of endoscopic papillary large-balloon dilation is a risk factor for perforation [54], especially when performed in combination with a large sphincterotomy during the same procedure [63].

ERCP with endoscopic snare papillectomy (ESP) is a risk factor for retroperitoneal perforation. In a study of 104 patients who underwent ESP, the perforation rate was 8 percent [64]. In a retrospective study, ESP had been performed in 7 out of 30 cases (23 percent) of duodeno-pancreato-biliary perforations reported after ERCP [65]. (See "Ampullary adenomas: Management".)

Other risk factors identified in individual reports include a small caliber bile duct [66], the presence of a peripapillary diverticulum [61,67], and intramural injection of contrast [59].

Biliopancreatic ductal perforation — Biliary stricture dilation increases the risk of biliopancreatic perforation [4].

CLINICAL MANIFESTATIONS AND DIAGNOSIS

Free abdominal perforation (type I perforation) is almost always recognized immediately based upon clinical symptoms, physical signs, and fluoroscopic findings. By contrast, retroduodenal perforation (type II) is usually determined by radiologic evidence of air (image 1) or by contrast material in the retroperitoneal space outside the confines of the bile duct and duodenum during ERCP (image 2) or computed tomographic (CT) evaluation for post-ERCP pain. However, type II perforations may be evident endoscopically (picture 1).

A retrospective series of ERCPs that included 61 type I or II duodenal perforations found that the diagnosis was made during the procedure in six patients (10 percent) and after the procedure in 54 patients (90 percent). The mean time to diagnosis was 24 (+/-13) hours [18]. However, other studies suggest that the rate of detection during ERCP may be higher [50,51]. For example, in a review of 18 studies with a total of 437 perforations, the diagnosis of perforation was made during ERCP in 321 cases (73 percent) [50].

Patients with undetected leaks can present hours after the procedure with pain, fever, and leukocytosis. Pneumomediastinum and subcutaneous emphysema can occur [21,68-72]. Pneumothorax [73] and gas in the portal system [74] have also been rarely described. Case reports have documented patients who developed pneumoretroperitoneum, pneumoperitoneum, pneumomediastinum, pneumothorax, and subcutaneous emphysema

following ERCP [75-78]. Indeed, an anatomic continuum exists between the retroperitoneum, pneumoperitoneum, mediastinum, pneumothorax, and subcutaneous tissues. As a result, ectopic air in one of these compartments can extend to distant communicating spaces [79].

An abdominal CT scan should be obtained in patients who are suspected of having a perforation, even if they do not have evidence of retroperitoneal air on plain films, since CT scan is the most sensitive means for detecting and localizing the site of perforation [80,81]. The clinical or radiographic amount of air does not always indicate the size of the perforation or correlate with the severity of the complication, but rather reflects the degree of manipulation after the perforation occurred [80,82].

Retroperitoneal air in asymptomatic patients — As discussed above, perforation is typically associated with the presence of retroperitoneal air, which can be detected by plain radiographs or CT. However, retroperitoneal air may also develop following sphincterotomy in patients who are clinically asymptomatic [81,83]. Such patients may not require intervention. This was illustrated in a series of 21 patients studied prospectively who underwent an abdominal CT scan following sphincterotomy. Retroperitoneal air was observed in six (29 percent) patients, all of whom were asymptomatic and had an uneventful postprocedural course [83]. No clinical or procedure-related characteristics predicted the presence of air.

The origin of retroperitoneal air in such patients is presumably related to dissection through an injured or macroscopically intact bowel, which has also been described after colonoscopy [84,85], although sealed microperforations are also possible. These findings suggest that retroperitoneal air in the absence of symptoms should warrant careful observation but may not require intervention.

Retroperitoneal perforation associated with pancreatitis — The finding of retroperitoneal air may be challenging in patients who are symptomatic following sphincterotomy in whom a distinction needs to be made between perforation, clinically insignificant retroperitoneal air, and pancreatitis, particularly since pancreatitis and perforation can have a similar clinical presentation or occur simultaneously [74,80,86]. This was illustrated in a study that included 36 patients who developed prolonged abdominal pain following sphincterotomy and underwent a diagnostic CT scan. Complications included acute pancreatitis in 23 patients (64 percent), duodenal perforation in 11 (31 percent), and both pancreatitis and duodenal perforation in six patients (17 percent) [80]. In a series that included 61 type I or II duodenal perforations, concurrent post-ERCP pancreatitis was diagnosed in 26 patients (43 percent) and was associated with increased mean length of stay [18]. In another series, two of three perforations in patients with Billroth II anatomy were associated with acute pancreatitis [87]. The diagnosis of retroperitoneal duodenal perforation associated with pancreatitis should be based upon the

detection of retroperitoneal air or contrast in a symptomatic patient meeting criteria for post-ERCP pancreatitis (see "Post-endoscopic retrograde cholangiopancreatography (ERCP) pancreatitis").

A retroperitoneal abscess should be suspected in patients with post-ERCP pancreatitis who develop back pain and persistent fever [88].

GRADING

Post-ERCP retroperitoneal perforation can be graded as mild, moderate, or severe based upon a consensus definition [55,89]:

- Mild – Either of the following:
  - Procedure aborted because of adverse event
  - Unplanned hospital admission less than four nights in duration
- Moderate – Any of the following:
  - Unplanned hospital admission for four to 10 nights
  - Admission requiring intensive care for at least one night
  - Need for blood transfusion
  - Need for repeat endoscopy or interventional radiology
  - Intervention for integument injuries
- Severe – Any of the following:
  - Unplanned hospital admission >10 nights
  - Admission requiring intensive care for >1 night
  - Need for surgery
  - Permanent disability

MANAGEMENT

General principles — All patients should be kept fasting while receiving hydration, nasogastric or nasoduodenal suction, and intravenous antibiotics, with the possible exception of asymptomatic patients with small type III perforations of the pancreatic or bile duct. If immediately diagnosed, type I perforations (free bowel wall perforations) can sometimes be successfully treated endoscopically with the use of endoscopic clips, an over-the-scope clip

device, or endoscopic suturing device [18,90]. However, most patients with esophageal and free abdominal gastric, jejunal, or duodenal perforation usually require surgery [4,91].

By contrast, a less invasive approach to retroperitoneal perforation following sphincterotomy has been adopted, and this includes medical management and, for some patients, placement of a fully covered metal stent to seal the perforation [2,11,12,28,31]. However, early surgical consultation and careful observation is mandatory since the outcome may be poor in patients who do not receive prompt intervention if their condition worsens [1,92-95]. For example, in a retrospective study of 380 patients with ERCP-related perforation, 330 patients (87 percent) were managed nonoperatively, while 50 patients (13 percent) required surgical intervention [93]. For 20 of 50 surgical patients, surgery was performed 24 hours after ERCP, and delayed surgery was associated with higher rates of mortality and postoperative duodenal leak compared with early surgery (50 versus 20 percent, and 75 versus 23 percent, respectively).

Medical management — Patients with a post-ERCP perforation should be kept fasting while receiving intravenous hydration, nasogastric or nasoduodenal suction, and intravenous antibiotics. Patients who are expected to require bowel rest for at least one week should receive parenteral nutrition.

Surgery — Overall, surgery was required in 20 to 50 percent of patients with a perforation in most reports, although mostly for type I free bowel perforations [3,4,11,12,18,22,32-36,50,52,59,65,91,96-98]. Surgery should be performed for patients with a major contrast leak, persistent biliary obstruction, or cholangitis, and for those whose symptoms do not improve after a brief period of nonoperative management [99]. Surgical options include choledochotomy with stone extraction and T-tube drainage, repair of the perforation, drainage of an abscess or phlegmon, choledochojejunostomy, or pancreatoduodenectomy [65,99-102]. (See "Repair of common bile duct injuries".)

The location of the perforation in cases of ERCP-associated injury may not be identified at laparotomy, especially in patients with type II or III perforations [11]. For patients with perforation complicated by a retroperitoneal fluid collection, a surgical approach using a retroperitoneal laparostomy has been reported [65].

Surgical repair is associated with a higher mortality rate than medical management. In a review that included 11 studies, surgery was required in 29 of 137 patients with type II perforations (21 percent), with an overall mortality rate of 9 percent. However, the mortality rate in patients who required surgery was 38 percent (11 of 29 patients) [50].

Endoscopic therapy — Endoscopic interventions to manage ERCP-related perforations include:

- **First-line techniques** – Placement of either a fully covered self-expandable metal stent (SEMS) or an over-the-scope clip are first-line endoscopic interventions for managing ERCP-related perforation:

  - Fully covered SEMS – Temporary placement of a biliary, fully covered SEMS is effective for treating ERCP-related retroperitoneal perforation. When the perforation is diagnosed during the index procedure, it can be treated immediately with stenting (image 2 and picture 2) [18,103-108]. In a case series including 19 patients with type II perforation who were managed with a fully covered SEMS either during the index procedure or up to 48 hours later, none of the patients required further intervention (ie, surgical or percutaneous intervention) [109]. (See 'Classification' above.)

  - Over-the-scope clip – Data from case reports suggest that post-ERCP perforation can be effectively managed with placement of an over-the-scope clip. As examples, an over-the scope clip device was used to close a post-ERCP jejunal perforation in a patient with Billroth II anatomy [110] and a large post-ERCP retroperitoneal duodenal perforation (picture 3 and picture 4 and image 3) [111]. Endoscopic therapy with over-the-scope clip closure is typically used for patients who are not surgical candidates, do not have sepsis, and have minimal or no peritoneal fluid collection [112]. Use of an over-the-scope clip device is discussed in more detail separately. (See "Endoscopic clip therapy in the gastrointestinal tract: Bleeding lesions and beyond", section on 'Uses for over-the-scope endoscopic clips'.)

- **Other techniques**

  - Through-the-scope endoscopic clips – Effective and safe placement of metallic endoscopic clips in the treatment of duodenal perforation secondary to sphincterotomy has been reported [37,113,114]. Effective endoscopic closure of duodenal perforations caused by the tip of the endoscope during ERCP using endoscopic clips has also been reported [98,115,116]. However, endoscopic therapy of a duodenal perforation is more technically difficult than that of a colonic or gastric perforation.

  - Endoscopic purse-string suture – The endoscopic purse-string suture uses endoscopically placed loops and clips to repair perforations of the gastrointestinal tract. It has been reported that this technique was successfully employed with a double-lumen endoscope for closing a large perforation on the lateral duodenal wall [117].

- Fibrin glue – In a case report, the injection of fibrin glue proved effective in sealing a perforation located in the posterior wall of the duodenal bulb [118]. Fibrin sealant injection successfully occluded a retroperitoneal perforation after sphincterotomy in a case report where previously a CT-guided abscess drainage had been performed and the biliary orifice had been protected by a stent [119]. Additional study of the use of fibrin glue for perforations is needed.

- Endoscopic vacuum therapy – A case of successful drainage of an iatrogenic retroperitoneal duodenal perforation following ERCP with papillotomy that used a vacuum technique has been reported [120]. The distal end of a drainage tube, wrapped in a very thin, open-pore, double-layered drainage film and secured using a suture was inserted nasally and then advanced into the duodenal lumen under endoscopic view. A vacuum was applied, resulting in collapse of the stomach and duodenum around the tube. Gastric, biliary, and pancreatic secretions were drained via the open-pore tube. Once the perforation healed (after six days in the report), the tube was removed.

- If a fully covered SEMS is not available when perforation is diagnosed during the procedure, an alternative is placement of a nasobiliary drain to divert biliary secretions from the site of perforation [59]. A nasobiliary tube can be placed in an attempt to aspirate bile and minimize retroperitoneal contamination.

Percutaneous drainage — Percutaneous transhepatic drainage is an alternative to surgery for patients who develop localized retroperitoneal fluid collections [97,102]. Percutaneous transhepatic cholangiography and associated interventions are discussed separately. (See "Percutaneous transhepatic cholangiography in adults".)

PROGNOSIS

The prognosis of patients with an ERCP-related perforation depends upon the rapidity with which it is recognized, the clinical setting, and patient comorbidities. The overall mortality was 16 percent in an older report that summarized the outcomes of 153 perforations following endoscopic sphincterotomy [22]. Overall mortality was 6 percent (seven out of 115 patients) in five large series [4,38,59,96,121], and a mortality rate of 8 percent (20 out of 251 patients) was demonstrated in a subsequent review [122]. An overall mortality of 13 percent (four deaths among 30 cases) and a postoperative mortality of 27 percent (four deaths among 15 cases) were reported in a retrospective study [65]. The overall need for surgery after perforation was approximately 35 percent and the mortality was approximately 7 percent according to results from observational studies [1-4,11,12,27-48,51,52]. The lower mortality seen in many of the

subsequent studies may reflect the benefits related to a conservative team approach for the management of small retroperitoneal perforations and the use of biliary fully covered SEMS [109].

PREVENTION

Endoscopic strategies for reducing the risk of ERCP- and sphincterotomy-related perforation include [90]:

- Orientation of the sphincterotome between 11 and 1 o'clock.
- Step-by-step incision.
- Avoiding a "zipper" cut.
- Sphincterotomy length tailored to the size of papilla, length of the infundibulum, bile duct diameter, and eventual stone size.
- Selective use of precut (access) papillotomy by endoscopists with expertise in difficult biliary access. (See "Precut (access) papillotomy".)
- Appropriate technique in cases of altered anatomy such as peripapillary diverticulum and Billroth II gastrectomy. (See "Endoscopic retrograde cholangiopancreatography (ERCP) after Billroth II reconstruction" and "ERCP in patients with Roux-en-Y anatomy".)
- Use of balloon dilation in conjunction with sphincterotomy in patients with large bile duct stones rather than relying on sphincterotomy alone [123-125], although severe perforations have been noted with this technique as well [124]. In a retrospective study comparing small sphincterotomy combined with endoscopic papillary large balloon dilation (group A) versus sphincterotomy alone (group B) for removal of large common bile duct stones involving a total of 153 patients, there were no perforations in either group and the rate of bleeding was significantly lower in group A (1.6 versus 5.6 percent) [126]. (See "Endoscopic balloon dilation for removal of bile duct stones".)
- Use of carbon dioxide for insufflation during ERCP is common and can theoretically minimize retroperitoneal gas in the event of ERCP-related perforation [54,127]. Carbon dioxide is rapidly absorbed from the gastrointestinal tract, and benefits of carbon dioxide for insufflation during endoscopy are discussed separately. (See "Overview of endoscopic retrograde cholangiopancreatography (ERCP) in adults", section on 'Gas insufflation' and

"Overview of colonoscopy in adults", section on 'Colonoscope advancement and mucosal inspection'.)

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Endoscopic retrograde cholangiopancreatography (ERCP)" and "Society guideline links: Gastrointestinal perforation".)

INFORMATION FOR PATIENTS

UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5th to 6th grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10th to 12th grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or e-mail these topics to your patients. (You can also locate patient education articles on a variety of subjects by searching on "patient info" and the keyword(s) of interest.)

- Beyond the Basics topics (see "Patient education: ERCP (endoscopic retrograde cholangiopancreatography) (Beyond the Basics)")

SUMMARY AND RECOMMENDATIONS

- **Classification** – Four types of perforation complicating endoscopic retrograde cholangiopancreatography (ERCP) have been recognized. (See 'Classification' above.):
  - Type I: Free duodenal wall perforation
  - Type II: Retroperitoneal duodenal perforation secondary to periampullary injury
  - Type III: Perforation of the pancreatic or bile duct
  - Type IV: Retroperitoneal air alone

- **Incidence** – Retroduodenal perforation was reported in 0.5 to 2.1 percent of patients who had ERCP with sphincterotomy in older series. Over time, the incidence of perforation has appeared to decrease to less than 0.5 percent, probably because of improvements in instruments, accessories, and endoscopist experience and skill. (See 'Incidence' above.)

- **Clinical features and diagnosis** – Free abdominal, intraperitoneal perforation is almost always recognized immediately based on endoscopic and fluoroscopic findings, clinical symptoms, and physical signs. In contrast, retroduodenal perforation is usually determined by radiologic evidence of air or contrast in the retroperitoneal space outside the confines of the bile duct and duodenum during computed tomographic (CT) evaluation for post-ERCP abdominal pain. Retroperitoneal perforation is rarely evident endoscopically. (See 'Clinical manifestations and diagnosis' above.)

  Retroperitoneal air may also develop following sphincterotomy in patients who are clinically asymptomatic. Such patients may not require treatment. (See 'Retroperitoneal air in asymptomatic patients' above.)

  An abdominal CT scan should be obtained in patients who are suspected of having a perforation, even if they do not have evidence of retroperitoneal air on plain films, since CT scan is the most sensitive method for detecting perforation.

- **Management** – Most patients with esophageal and free abdominal gastric, jejunal, or duodenal perforation require surgery. For some patients, in whom ERCP-related perforation is diagnosed during the procedure, an endoscopic intervention to seal the perforation (eg, placement of a fully covered self-expandable metal stent or over-the-scope clip) may be used when expertise in endoscopic closure methods is available.

  For patients with a small retroperitoneal perforation related to sphincterotomy, medical management may be appropriate. However, careful observation along with surgical consultation is mandatory since the outcome may be poor in patients who do not receive prompt treatment if their condition worsens. (See 'Management' above.)

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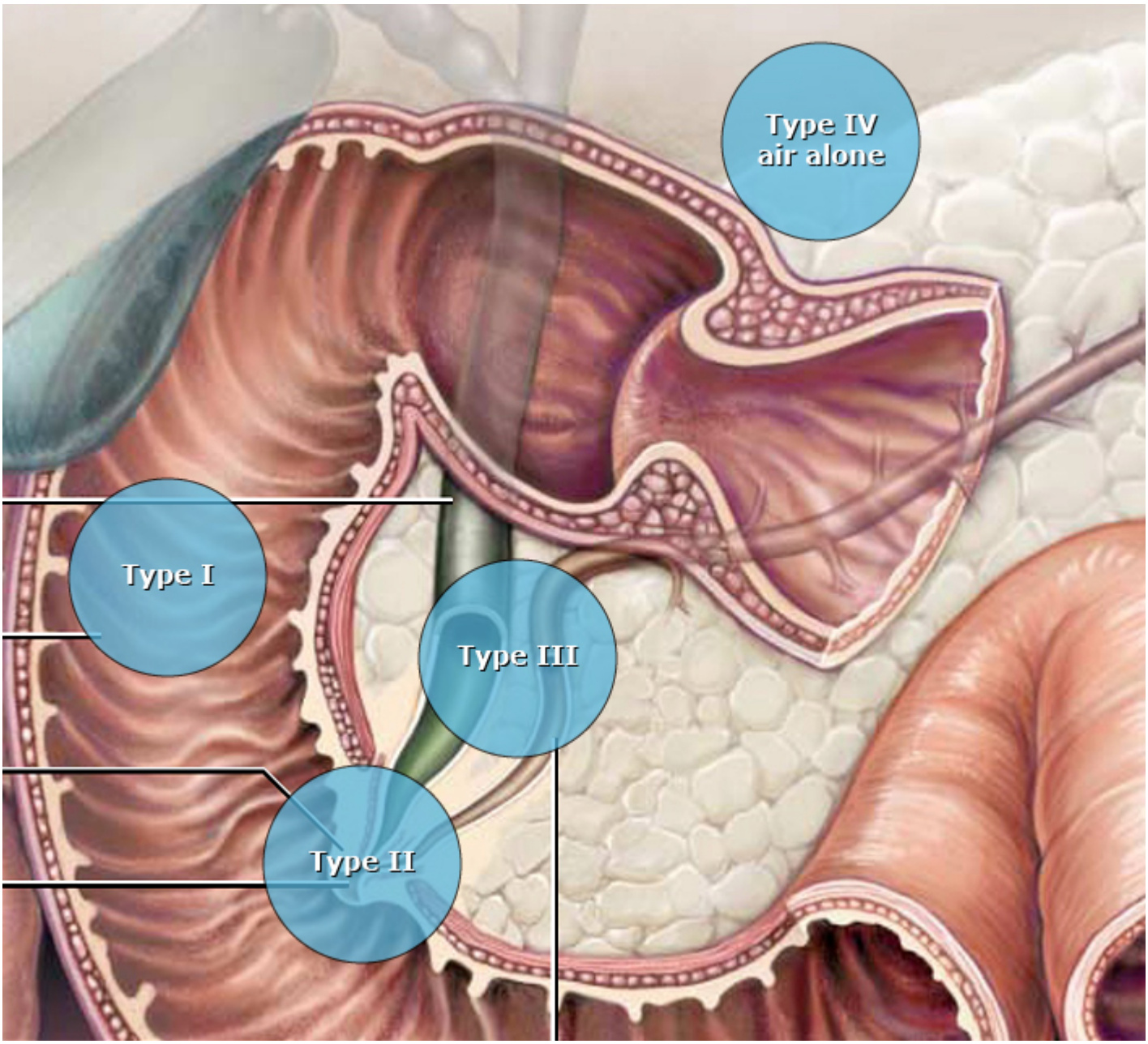
Topic 634 Version 33.0

GRAPHICS

The Stapfer classification of ERCP-related perforations

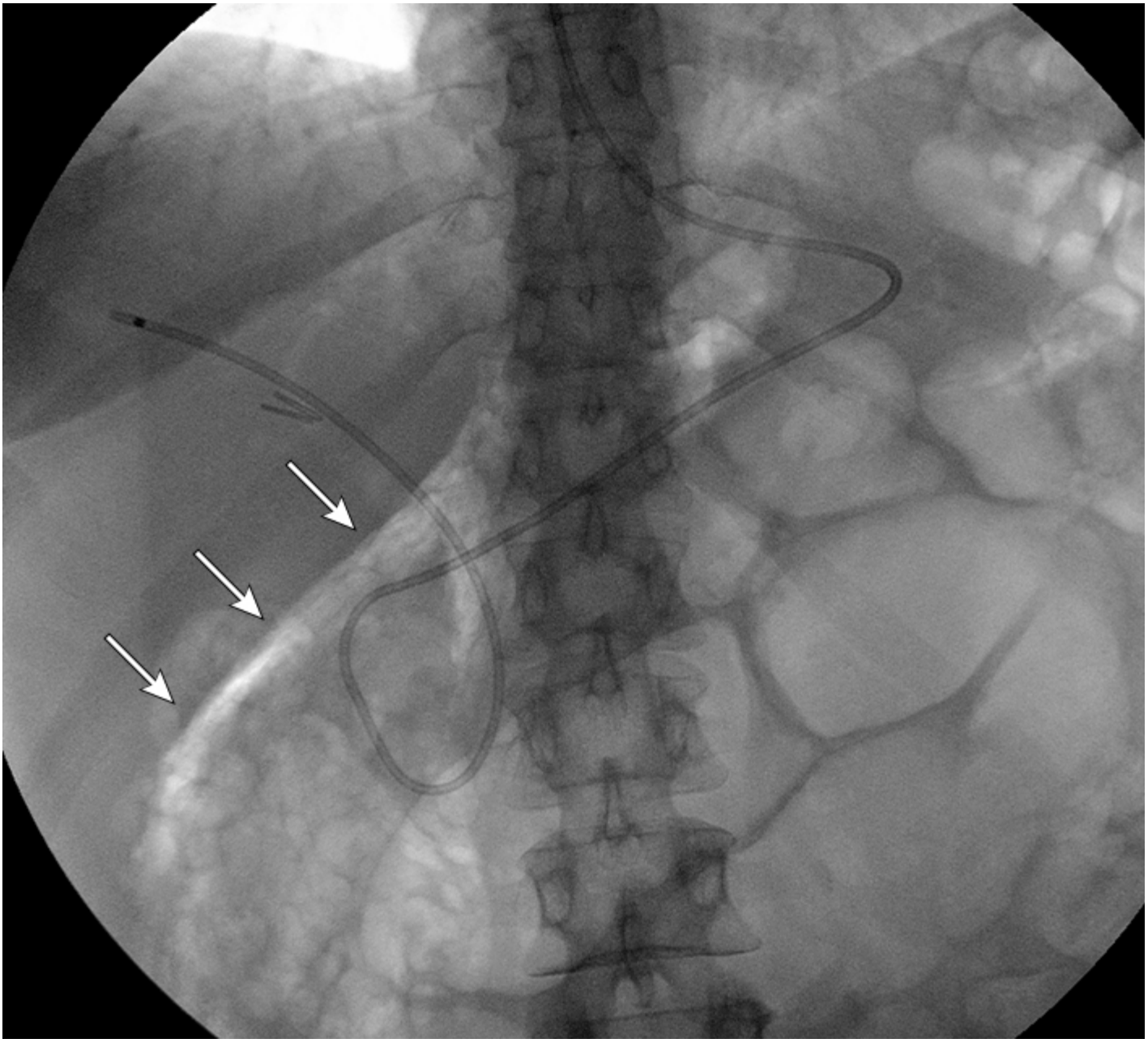


The Stapfer classification divides ERCP-related perforations into four types based on the mechanism, anator location, and severity of injury. The four types of perforations are: Type I, lateral or medial wall duodenal perforation; type II, periampullary injuries; type III, bile duct or pancreatic duct injuries; and type IV, retroperitoneal air alone.

ERCP: endoscopic retrograde cholangiopancreatography.

Graphic 113305 Version 1.0

ERCP-related retroduodenal perforation (Type II)

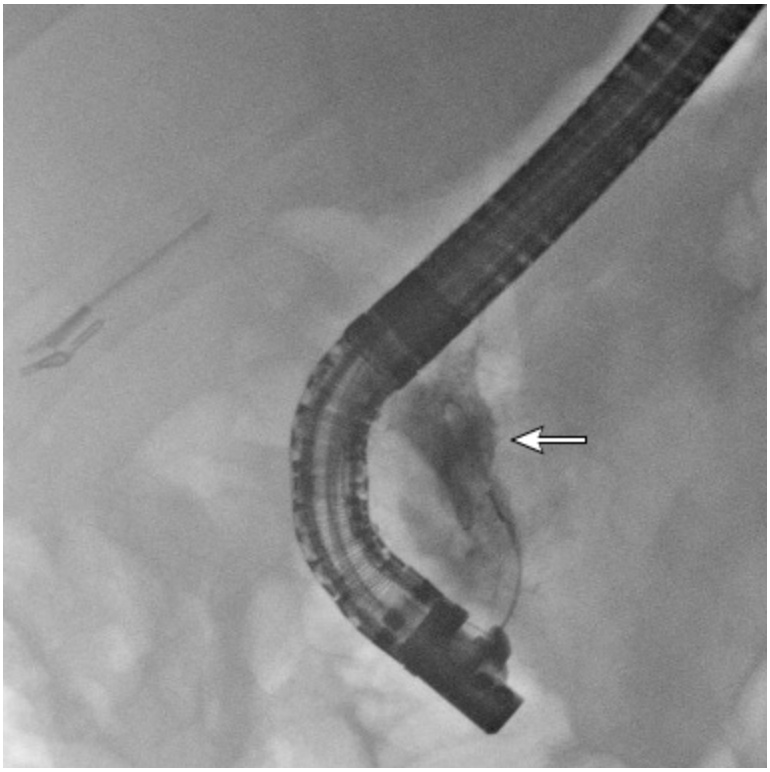


Diagnostic image showing ERCP-related retroduodenal perforation (Type II). Retroperitoneal air (arrows) is identified during ERCP and a nasobiliary drain is immediately placed for bile drainage.

ERCP: endoscopic retrograde cholangiopancreatography.

Graphic 113307 Version 1.0

Retroduodenal perforation related to ERCP

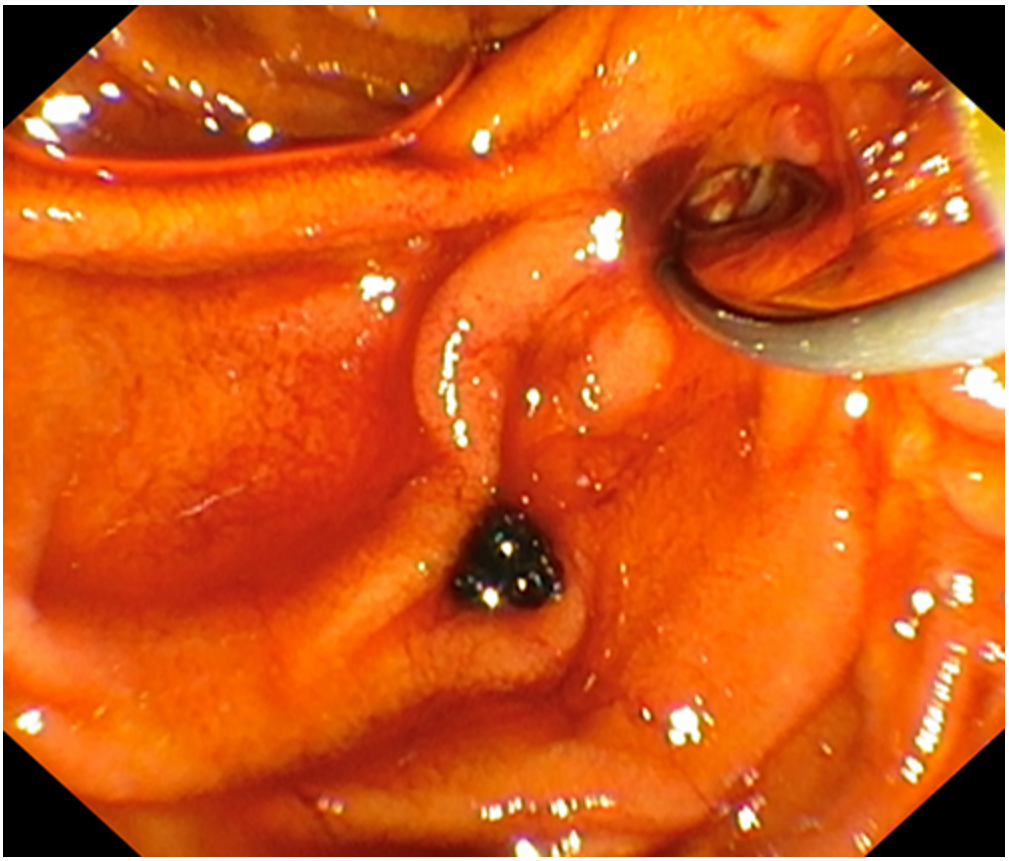


This diagnostic image shows a retroduodenal perforation with contrast in the retroperitoneal space (arrow) and outside the confines of the bile duct.

Courtesy of Dr. Andrea Tringali, Digestive Endoscopy Unit, Policlinico Gemelli Foundation IRCCS Catholic University – Rome, Italy.

Graphic 139692 Version 1.0

Endoscopic view of a retroperitoneal duodenal perforation following biliary sphincterotomy

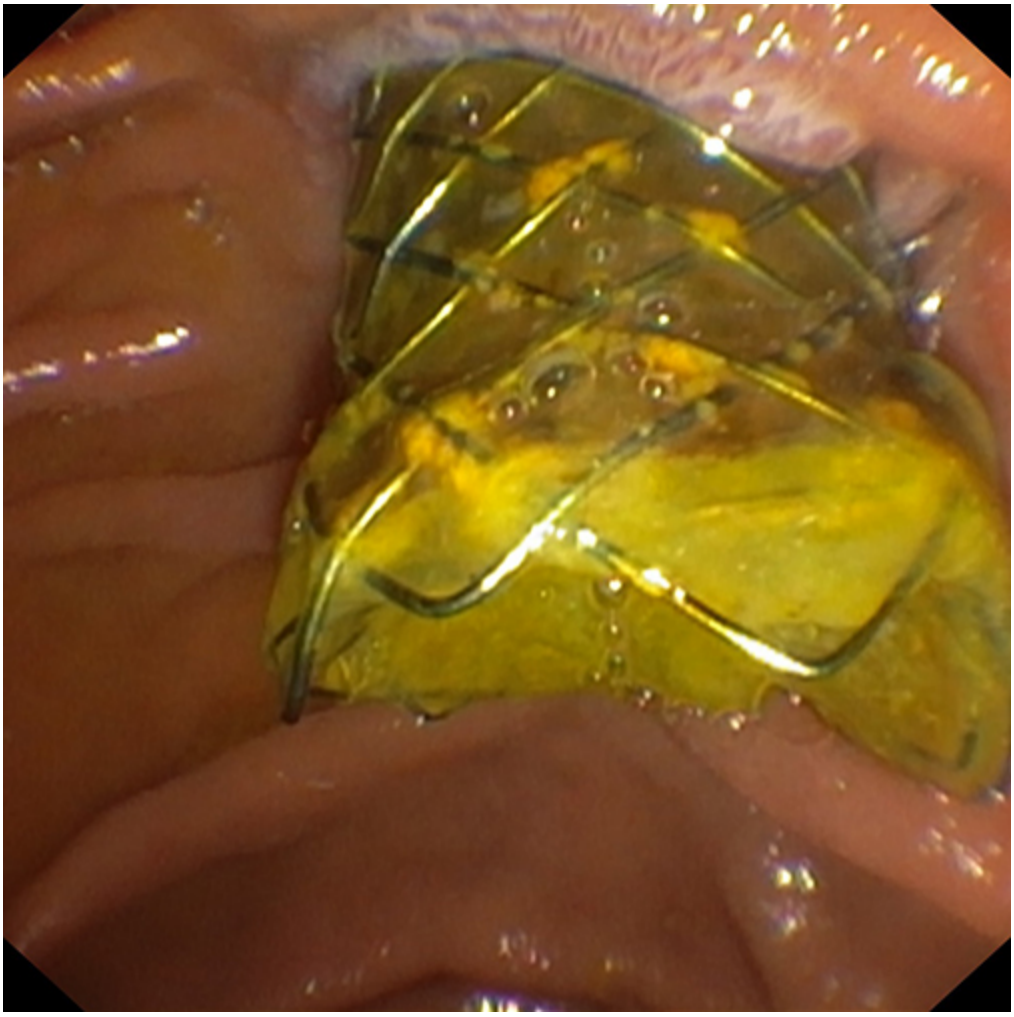


This picture demonstrates an endoscopic view of a retroperitoneal perforation following biliary sphincterotomy and bile duct stone removal.

Courtesy of Dr. Andrea Tringali, Digestive Endoscopy Unit, Policlinico Gemelli Foundation IRCCS Catholic University – Rome, Italy.

Graphic 64568 Version 3.0

Stent placement for perforation

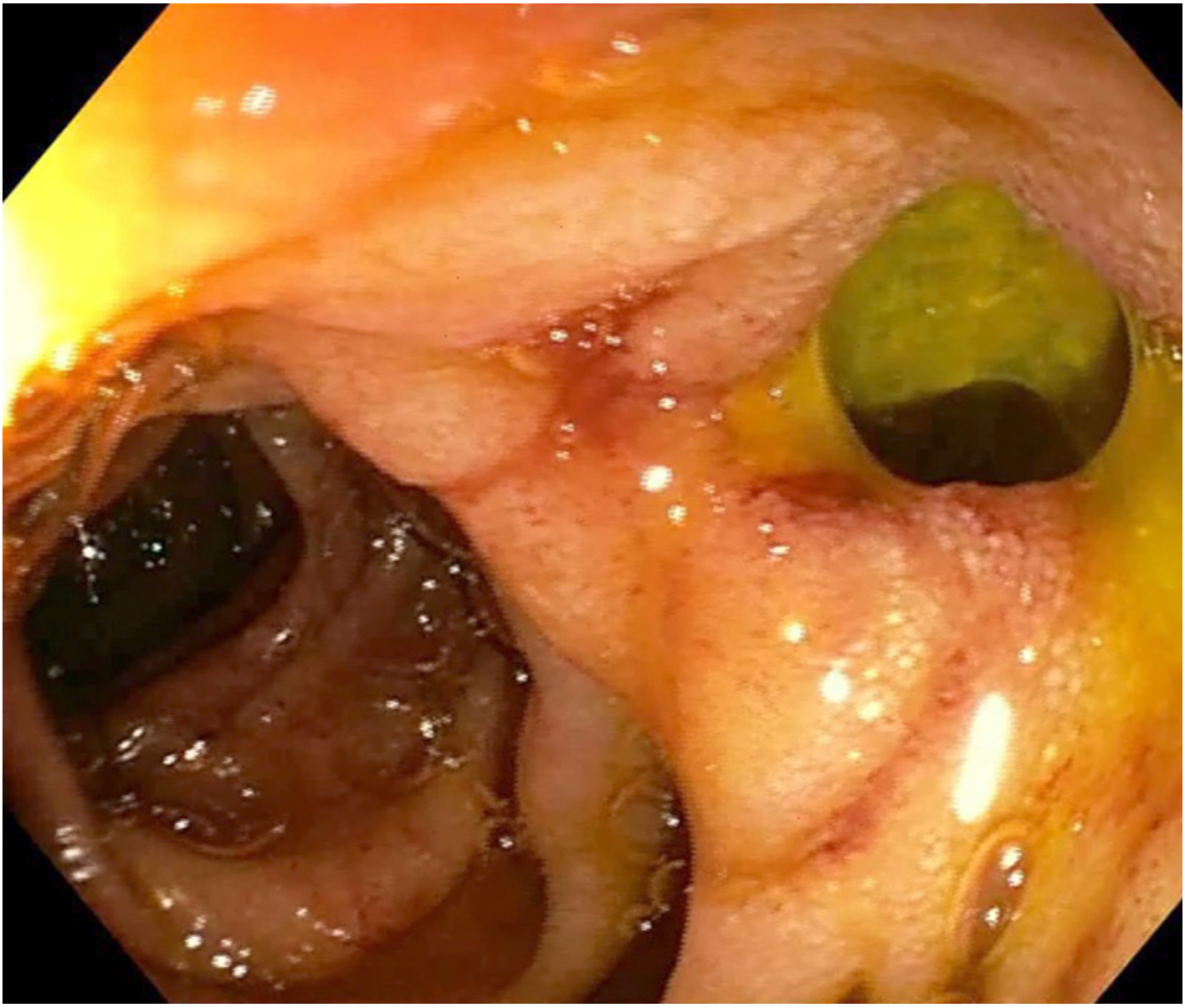


This endoscopic picture shows a fully covered, self-expandable metal stent that was placed in the bile duct to close a sphincterotomy-related perforation. Temporary stent placement allowed the perforation to heal.

Courtesy of Dr. Andrea Tringali, Digestive Endoscopy Unit, Policlinico Gemelli Foundation IRCCS Catholic University – Rome, Italy.

Graphic 139693 Version 1.0

Endoscope-related duodenal perforation

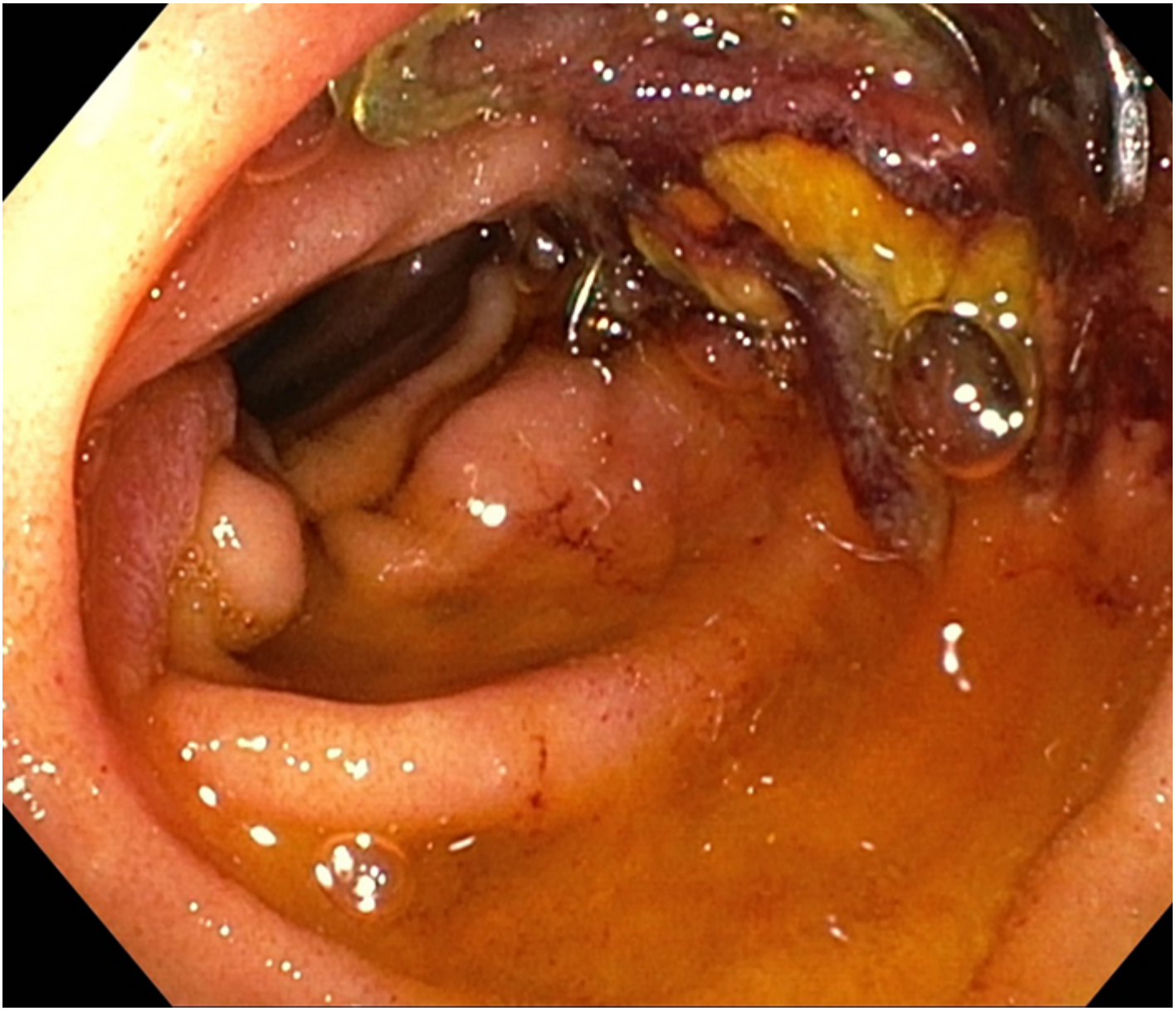


This picture demonstrates an endoscope-related duodenal perforation in a patient undergoing endoscopic retrograde cholangiopancreatography (ERCP).

Courtesy of Dr. Andrea Tringali, Digestive Endoscopy Unit, Policlinico Gemelli Foundation IRCCS Catholic University – Rome, Italy.

Graphic 139037 Version 1.0

Closure of duodenal perforation with over-the-scope clip

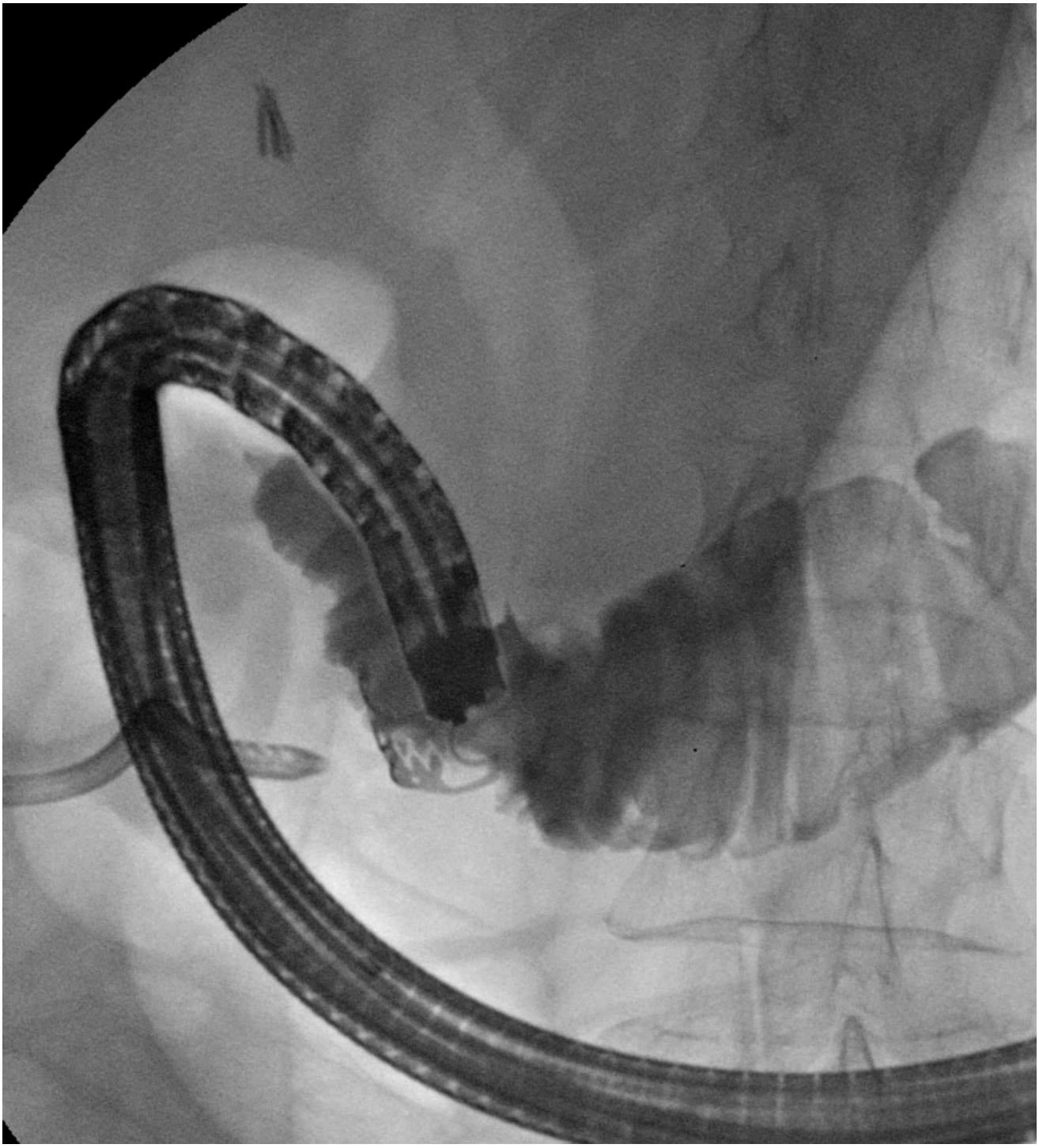


This picture demonstrates an endoscopic view of closure of a duodenal perforation using an over-the-scope

Courtesy of Dr. Andrea Tringali, Digestive Endoscopy Unit, Policlinico Gemelli Foundation IRCCS Catholic University – Rome, Italy.

Graphic 138886 Version 1.0

Contrast injection confirms successful closure of duodenal perforation



Contrast injection with fluoroscopic imaging confirms successful closure of a duodenal perforation using an over-the-scope clip.

Courtesy of Dr. Andrea Tringali, Digestive Endoscopy Unit, Policlinico Gemelli Foundation IRCCS Catholic University – Rome, Italy.

Graphic 138887 Version 1.0

Contributor Disclosures

Andrea Tringali, MD, PhD Consultant/Advisory Boards: Boston Scientific [Cholangioscopy]; Olympus [Cholangioscopy]. All of the relevant financial relationships listed have been mitigated. **Silvano Loperfido, MD** No relevant financial relationship(s) with ineligible companies to disclose. **Guido Costamagna, MD, FACG** Grant/Research/Clinical Trial Support: Boston Scientific [Endoscopic retrograde cholangiopancreatography]; Cook [Endoscopic retrograde cholangiopancreatography]; Olympus [Endoscopic retrograde cholangiopancreatography]. Consultant/Advisory Boards: Cook [Endoscopic retrograde cholangiopancreatography, therapeutic endoscopy]; Olympus [Endoscopic retrograde cholangiopancreatography, therapeutic endoscopy]. All of the relevant financial relationships listed have been mitigated. **John R Saltzman, MD, FACP, FACG, FASGE, AGAF** No relevant financial relationship(s) with ineligible companies to disclose. **Kristen M Robson, MD, MBA, FACG** No relevant financial relationship(s) with ineligible companies to disclose.

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Conflict of interest policy

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