Communication from the ASGE Standards of Practice Committee

GUIDELINE

# Adverse events of upper GI endoscopy

*This is one of a series of statements discussing the use of GI endoscopy in common clinical situations. The Standards of Practice Committee of the American Society for Gastrointestinal Endoscopy (ASGE) prepared this text. In preparing this document, a search of the medical literature was performed by using PubMed. Additional references were obtained from the bibliographies of the identified articles and from recommendations of expert consultants. When few or no data exist from well-designed prospective trials, emphasis is given to results of large series and reports from recognized experts. This document is based on a critical review of the available data and expert consensus at the time that the document was drafted. Further controlled clinical studies may be needed to clarify aspects of this document. This document may be revised as necessary to account for changes in technology, new data, or other aspects of clinical practice.*

*This document is intended to be an educational device to provide information that may assist endoscopists in providing care to patients. This document is not a rule and should not be construed as establishing a legal standard of care or as encouraging, advocating, requiring, or discouraging any particular treatment. Clinical decisions in any particular case involve a complex analysis of the patient's condition and available courses of action. Therefore, clinical considerations may lead an endoscopist to take a course of action that varies from this document.*

Upper GI (UGI) endoscopy is commonly performed and carries a low risk of adverse events. Large series report adverse event rates of 1 in 200 to 1 in 10,000 and mortality rates ranging from none to 1 in 2000.[1-6] Data collected from the Clinical Outcomes Research Initiative database show a cardiopulmonary event rate of 1 in 170 and a mortality rate of 1 in 10,000 from among 140,000 UGI endoscopic procedures.[7] The variability in rates of adverse events may be attributed to the method of data collection, patient populations, duration of follow-up, and definitions of adverse events. Some authors include minor incidents, such as transient hypoxemia or self-limited bleeding as adverse events, whereas others report only significant adverse events that prevent completion of the procedure or result in hospitalization.[8] Additionally, the majority of publications rely on self-reporting, and most reported data collected only from the immediate periprocedure period, thus the rate of late adverse events and mortality may be underestimated.[8,9] Major adverse events related to diagnostic UGI endoscopy are rare and include cardiopulmonary adverse events, infection, perforation, and bleeding. Adverse events of ERCP and EUS are discussed in separate ASGE documents.[10,11]


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## ADVERSE EVENTS ASSOCIATED WITH DIAGNOSTIC UGI ENDOSCOPY

### Cardiopulmonary adverse events

Most UGI procedures in the United States and Europe are performed with patients under sedation (moderate or deep).[12] Cardiopulmonary adverse events related to sedation and analgesia account for as much as 60% of UGI endoscopy adverse events.[1-4,7] The rate of cardiopulmonary adverse events in large, national studies is between 1 in 170 and 1 in 10,000.[1-4,6,7] Reported adverse events range from minor incidents, such as changes in oxygen saturation or heart rate, to significant adverse events such as aspiration pneumonia, respiratory arrest, myocardial infarction, stroke, and shock. Patient-related risk factors for cardiopulmonary adverse events include preexisting cardiopulmonary disease, advanced age, American Society of Anesthesiologists class III or higher, and an increased modified Goldman score.[13,14] Procedure-related risk factors for hypoxemia include difficulty with intubating the esophagus, a prolonged procedure, and a patient in the prone position.[7,8,15,16] For a detailed discussion and specific recommendations, the reader is referred to the ASGE document "Sedation and Anesthesia in GI Endoscopy"[17] and the "American Society of Anesthesiology Practice Guidelines for Sedation and Analgesia by Nonanesthesiologists."[18]

### Infectious adverse events

Infectious adverse events of diagnostic UGI endoscopy can result from either the procedure itself or failure to follow guidelines for the reprocessing and use of endoscopic devices and accessories.[19,20] Transient bacteremia as a result of diagnostic UGI endoscopy has been reported at rates as high as 8%, but the frequency of infectious endocarditis and other clinical sequelae is extremely low.[21,22] Current American Heart Association and ASGE guidelines do not recommend antibiotic prophylaxis with

diagnostic UGI endoscopy solely to prevent infectious endocarditis.[20,23]

### Perforation

Prospective, multicenter registries report perforation rates of 1 in 2500 to 1 in 11,000.[4,24] Factors predisposing to perforation include the presence of anterior cervical osteophytes, Zenker's diverticulum, esophageal stricture, malignancies of the UGI tract, and duodenal diverticula.[24,25] Perforation of the esophagus is associated with a mortality rate between 2% and 36%.[26-29] Early identification and expeditious management of a perforation have been shown to decrease associated morbidity and mortality.[29,30]

### Bleeding

Clinically significant bleeding is a rare adverse event of diagnostic UGI endoscopy.[31] Mallory-Weiss tears occur in less than 0.5% of diagnostic UGI endoscopic procedures and usually are not associated with significant bleeding.[32] Bleeding may be more likely in individuals with thrombocytopenia and/or coagulopathy.[1] The minimum threshold platelet count for the performance of diagnostic UGI endoscopy has not been established. UGI endoscopy with biopsy was shown to be safe in 1 study of adults with solid malignancies and platelet counts greater than 20,000/mL.[33] Two case series of UGI endoscopy with or without biopsies in children with platelet counts greater than 50,000/mL reported no bleeding adverse events.[34,35] However, a larger study of 198 UGI endoscopies in children after stem cell transplantation demonstrated that the risk of bleeding requiring red blood cell transfusions after UGI endoscopic biopsies was 4% despite a minimum platelet count of 50,000/mL.[36] Four of these 8 patients were found to have duodenal hematomas. Thus, some authors have concluded that diagnostic UGI endoscopy can be performed when the platelet level is 20,000/mL or greater and that a threshold of 50,000/mL should be considered before performing biopsies.[37-40]

## ADVERSE EVENTS OF ENDOSCOPIC INTERVENTIONS

### Adverse events of UGI dilation

Data from randomized trials and large case series suggest that the overall rate of dilation adverse events is between 0.1% and 0.4%.[1,41-44] The most common adverse events are perforation, hemorrhage, aspiration, and bacteremia. Most dilation-related bleeding is self-limited, but rare episodes of bleeding requiring endoscopic hemostasis and dissection into major blood vessels have been reported.[45,46] Patients with significant obstruction of the UGI tract may be at risk of aspiration of retained food and fluid. In these situations, measures to avoid aspiration should be considered (eg, nasogastric suction before sedation, reverse Trendelenburg position), and, when appropriate, placement of an endotracheal tube for airway protection. Although the incidence of bacteremia with UGI dilation ranges from 12% to 22%, infectious sequelae are rare.[47] Therefore, antibiotic prophylaxis is not recommended.[20]

**Dilation of esophageal strictures.** The most common adverse events of esophageal dilation are perforation and bleeding. Wire-guided bougie dilation or through-the-scope balloon dilation may have lower risks of adverse events than blind passage of dilators.[42] Randomized trials suggest that wire-guided polyvinyl dilators and through-the-scope balloons have similar rates of both efficacy and adverse events.[41,44,48,49]

The rate of perforation after esophageal dilation for esophageal rings and simple peptic strictures is lower than that of certain high-risk lesions. Dilation of complex strictures (angulated, multiple, or long) with Maloney dilators may be associated with a 2% to 10% risk of perforation[50,51] so wire-guided or balloon dilation is likely a safer alternative.[42] Dilation of caustic strictures, which tend to be long and angulated, is associated with a higher rate of adverse events.[52,53] Dilation of eosinophilic esophagitis is associated with a high incidence of mucosal tears, but only 1 perforation was identified in a systematic review of 671 dilations for eosinophilic esophagitis.[54] The risk of perforation resulting from dilation of malignant strictures of the esophagus is approximately 10%[55,56] and is associated with increasing dilator diameter.[56-59] Radiation-induced strictures have also been reported to have a high rate of dilation-related adverse events,[60] but this risk may be related to the presence of malignancy rather than the effect of radiation.[61]

Pain is the most common symptom related to perforation.[25,26,62,63] Fever, crepitus, pleuritic chest pain, leukocytosis, and pleural effusion may also be present. Perforation with associated air dissection may be diagnosed by plain radiography of the neck and/or chest, but such findings may be absent immediately after perforation.[64] If a perforation is suspected, contrast esophagography should be performed, usually beginning with water-soluble contrast.[65] If the site of perforation cannot be determined but suspicion remains high, a barium esophagram or CT scan of the chest is indicated. A CT scan with oral contrast is sensitive for the site of perforation and for more subtle findings such as minute amounts of air or fluid.[66]

The approach to the patient with perforation depends on the state of health of the individual, the site of the perforation, and the overall prognosis. In selected patients, early recognition may allow nonoperative management with nasogastric suction, intravenous antibiotics, and parenteral nutrition.[27] Surgical consultation should be obtained, and surgical management is recommended for larger perforations in which the pleural space is involved or for failure to respond to medical management.[28,29] Case series of successful endoscopic closure of esophageal perforation with endoluminal stents, endoscopic clips, or su-

turing devices have been published,[67-71] although comparative data are lacking.

**Dilation for achalasia.** Pneumatic dilation of the lower esophageal sphincter is associated with increased risk of postprocedure pain, aspiration, bleeding, and perforation.[72,73] The rate of perforation is between 1.6% and 8%.[73,74] The risk of perforation may be lower when interval, graded dilation is used, beginning with a 30-mm diameter balloon and progressing to larger diameter balloons, only if symptoms do not improve. Using this technique, the overall risk of perforation is reported to be less than 2%.[75-77] Contrast esophagography should be performed for patients with persistent postprocedure pain, tachycardia, fever, or subcutaneous crepitus. Nonoperative management with nasogastric tube decompression and intravenous antibiotics may be used for contained perforations caused by pneumatic dilation.[78] Perforations resulting in extravasation of contrast during postprocedure esophagography may require operative intervention.[77]

**Dilation for benign gastric outlet obstruction.** Endoscopic balloon dilation for benign gastric outlet obstruction has been associated with perforation rates as high as 7.4%.[79-84] Risk factors for perforation include dilation in the setting of active ulceration[83] and dilation with balloons greater than 15 mm in diameter.[80,82,83,85] Graded dilation with stepwise increase of balloon size has been suggested to help reduce the risk of perforation.[82,86]

## Adverse events of foreign body retrieval

Adverse events attributable to endoscopic removal of foreign bodies are rare, and it can be difficult to determine whether the adverse event was caused by UGI endoscopy or the foreign object itself.[87,88] The most commonly reported adverse events are superficial mucosal laceration (≤2%), GI hemorrhage (≤1%), and perforation (≤0.8%).[89-96] Risk factors for perforation include removal of sharp, irregular objects, a delay of more than 24 to 48 hours to endoscopic intervention, and a history of repeated intentional foreign body ingestion.[87,88,91,96-99] Aspiration during endoscopic extraction of foreign bodies from the UGI tract is rarely reported[91,96] but deserves attention, especially when removing food piecemeal from the esophagus. The risk of aspiration may be minimized by using an esophageal overtube and/or endotracheal intubation. Injury during removal of sharp objects can be minimized by removing the object such that the sharp edge is trailing or by using an overtube.[100] After extraction of the foreign body, reinsertion of the endoscope should be performed to assess the mucosa for lacerations, bleeding, and the presence of underlying strictures or other pathology. Most mucosal injuries can be treated conservatively, and active bleeding that is not self-limited can be treated with standard endoscopic hemostasis techniques.[100] Further discussion of the management of foreign bodies can be found in a recent ASGE publication.[101]

## Adverse events of percutaneous endoscopic enteral access

The overall rate of adverse events with PEG placement is reported to be 4.9% to 10.3%.[102] Serious adverse events occur in 1.5% to 9.4% of PEG procedures and include aspiration, bleeding, injury to internal organs, perforation, "buried bumper syndrome," prolonged ileus, wound infection, necrotizing fasciitis, and death.[102,103] In a meta-analysis of 4194 PEG procedures, minor adverse events occurred in approximately 6% of patients and included tube occlusion, maceration from feeding tube leakage, and peristomal pain. PEG procedure–related mortality was reported to be 0.53% with a 30-day all-cause mortality rate of 14.7%.[103]

Peristomal wound infections are the most common infectious adverse events, occurring in 7% to 47% of patients receiving placebo in clinical trials. The pooled rate of wound infection in a meta-analysis of 10 randomized clinical trials was 26%.[104] A single dose of cephalosporin or penicillin-based prophylaxis resulted in a clinically significant reduction in PEG site wound infections,[104] and antibiotic prophylaxis for PEG placement is both cost-effective[105] and recommended for routine use.[20] Necrotizing fasciitis is a rare but serious adverse event with risk factors that include diabetes mellitus, atherosclerosis, alcoholism, malnutrition, immunosuppression, and older age.[105-107] Aspiration pneumonia may develop at the time of PEG placement, especially in those with oropharyngeal dysphagia.[108,109] Whether these patients aspirate during the procedure itself or aspirate their own secretions or tube-feeding material is difficult to ascertain. Pneumoperitoneum is typically a benign occurrence, which has been reported in 12% to 38% of patients undergoing uncomplicated PEG.[110-112]

Bleeding from gastric or abdominal wall vessels is reported in less than 1% of procedures.[108,113] Anticoagulants should be held or reversed before PEG placement.[31] Injury to internal organs such as the liver, small bowel, and colon can occur during needle insertion.[114-118] Gastric tears are a rare occurrence during PEG placement.[108,119] Prevention of such injuries may be best achieved by ensuring adequate transillumination and finger indentation when placing the PEG and by use of the "safe-tract" technique.[120,121] The optimal management of gastric laceration, peritonitis, or colonic perforation is poorly studied, although surgical exploration will likely be required.[115] An asymptomatic or chronic cologastrocutaneous fistula may be treated with simple removal of the tube, and the fistula is reported to heal within hours.[122] Feeding tubes may become impacted in the abdominal wall.[123,124] The "buried bumper syndrome" is believed to result from excessive traction on the internal PEG bolster, causing ischemic necrosis of the gastric wall. Endoscopically, the PEG may not be visible. Treatment involves removal of the tube and placement of a new tube.[125]

Metastasis developing at the PEG insertion site in patients with head and neck cancers has been reported.[126] It is unclear whether this results from hematogenous spread or transport of exfoliated tumor cells during passage of the feeding tube past the tumor. If PEG-site metastasis is a concern for any particular patient, other techniques may be reasonable alternatives to a PEG.[127]

Accidental early tube removal may result in peritonitis if a mature fistulous tract has not developed. If a mature tract is present (>1 month), then a suitable replacement tube should be inserted as soon as possible. Contrast injection and fluoroscopy can be used to confirm correct tube location when there is uncertainty as to the maturity of the tract.[128,129]

Adverse events associated with percutaneous endoscopic jejunostomy are similar to those of standard PEG placement, although the rate is higher.[129-134] Adverse events unique to PEG with jejunal extension are typically caused by the small-diameter jejunal feeding extension and include clogging (4%-18%), unintentional removal (11%-18%), and tube migration (6%).[129,130,134,135]

## Adverse events of endoluminal therapy

**Resection techniques.** Endoscopic polypectomy in the UGI tract is associated with low rates of pain, bleeding, and perforation.[136] Immediate bleeding after gastric polypectomy is more common than bleeding after polypectomy at other sites, with rates ranging from 3.4% to 7.2%.[136-139] Delayed bleeding after polypectomy of duodenal adenomas is reported in 3.1% to 22% of patients.[140-142]

EMR is used to excise focal lesions of the mucosa and involves resection into the submucosal layer. Common self-limited adverse events of EMR include chest pain, abdominal pain, dysphagia, odynophagia, and dyspepsia.[143] The overall incidence of serious adverse events such as bleeding, perforation, and stricture has been estimated to be between 0.5% and 5%.[144] Bleeding occurs more often with multifocal EMR and with EMR of gastric lesions.[143-145] Perforation with gastric EMR is reported more frequently than with esophageal EMR, possibly because of the larger lesions encountered in the stomach.[146] Stricture formation is mostly reported after esophageal EMR, especially when circumferential resection is performed. The incidence of esophageal stricture after focal EMR is less than 0.5%, compared with an incidence of 12% to 35% when more than 50% of the esophageal circumference is resected.[145,147]

Endoscopic submucosal dissection (ESD) allows for en bloc excision of large mucosal lesions of the GI tract by using a variety of specialized accessories.[148,149] Adverse events of ESD are similar to those of EMR, but occur with greater frequency given the larger areas of resection. The overall incidence of bleeding and perforation with ESD is 11% and 6%, respectively.[143-146,148] Asymptomatic pneumomediastinum may occur in as many as 31% of ESDs and is of uncertain clinical significance.[150]

**Ablation techniques.** Ablation of mucosal lesions of the UGI tract can be performed with a variety of devices including heater probes, multipolar electrocoagulation, argon plasma coagulation (APC), and Nd-YAG laser. Self-limited adverse events commonly reported include pain, dysphagia, and nausea. The incidence of serious adverse events associated with APC appears to be higher than that of other modalities, especially when treating long segments of Barrett's esophagus or with multiple sessions of ablation.[151-154] Randomized trials with APC report bleeding rates of as high as 4%, esophageal perforation in as many as 2% of patients, and stricture formation in as many as 6% of patients.[151,155,156]

Photodynamic therapy (PDT) with porfimer sodium as a photosensitizing agent is used for palliation of dysphagia in advanced esophageal cancer and for ablation of Barrett's epithelium with high-grade dysplasia. PDT of the esophagus frequently causes chest pain, fever, and pleural effusion.[157,158] PDT with porfimer sodium results in esophageal stricture formation in 11% to 42% of patients.[155,159] Photosensitivity reactions occur in 10% to 60% of patients.[157,160]

Radiofrequency ablation (RFA) of Barrett's epithelium has a relatively favorable adverse event profile. In 1 randomized trial, the degree of chest discomfort was higher after RFA than in the control group, but resolved within 8 days of the procedure.[161] Superficial lacerations have been noted during 6% of procedures,[162] but bleeding requiring endoscopic therapy occurred in less than 2% of procedures.[161-164] The incidence of RFA-associated esophageal stricture ranges from 2% to 8%.[161-163] Procedure-related perforation has been reported.[165]

Cryotherapy has not been as well studied to date. Small case series report common self-limited symptoms such as pain and dysphagia. The incidence of strictures ranges between 4% and 10%.[166-168] Esophageal perforation was reported in 1 patient with Marfan syndrome undergoing liquid nitrogen cryotherapy.[167]

**Endoscopic stents.** Stents may be deployed endoscopically to achieve luminal patency in any part of the UGI tract. Rigid esophageal stents are no longer used and have been replaced by self-expanding stents.[169,170] Immediate adverse events of esophageal self-expandable metal stents (SEMSs) occur in 2% to 12% of patients and include aspiration, respiratory compromise caused by tracheal compression, improper positioning, and perforation.[170-173] Immediate adverse events may be minimized by adequate patient preparation and positioning, familiarity of the endoscopist with the stent mechanism and characteristics, the use of soft-tipped guidewires, and avoidance of aggressive prestent dilation.[174,175] Early postdeployment adverse events, such as chest pain and nausea, are common and resolve with conservative measures in most cases.[170,176,177] Significant bleeding after SEMS placement

is not common, but may be life-threatening.[178] Late adverse events after esophageal SEMS placement occur in 20% to 40%.[179] Pyrosis and regurgitation are common when the gastroesophageal junction is bridged with a stent. Strict antireflux measures, high-dose acid suppression, and the use of stents designed to prevent reflux have been used with varying degrees of success.[180-182] Recurrent occlusion of SEMS is reported in as many as 30% of patients and can occur because of tumor overgrowth, tissue hyperplasia at the ends of the stent, stent migration, or food impaction.[173] The use of covered stents reduces the risk of tumor ingrowth.[173,177] Occlusion by tissue may be treated by endoscopic ablation of the tissue or placement of a second stent.[183] Food impactions may be managed endoscopically.[184] Late perforation of the esophagus caused by ischemia of the esophageal wall and tracheoesophageal fistulae have been reported.[178,183,184] Pretreatment with chemoradiotherapy has been reported to increase the incidence of adverse events of esophageal SEMSs by some authors[185] but not by others.[186,187]

Gastroduodenal stents are associated with similar adverse events as esophageal SEMS. Severe early adverse events, such as bleeding and perforation, are reported in 1% to 5% of patients.[188-190] Aspiration is a significant concern during initial placement, and precautions for airway protection should be taken.[175] Stent migration, early malfunction or occlusion, and late stent occlusion are common adverse events of gastroduodenal stents.[191] The rate of reintervention for SEMS placed in patients with malignant gastroduodenal obstruction is 20% to 30%. [188,191-193]

## Endoscopic variceal hemostasis

**Endoscopic variceal sclerotherapy (EVS).** The sclerosants used for EVS include sodium tetradecyl sulfate, sodium morrhuate, ethanolamine oleate, absolute alcohol, and cyanoacrylate. No single sclerosant has demonstrated superiority over the others. The overall adverse event rate from EVS has been estimated to be between 35% and 78%, with a mortality rate of 1% to 5%.[194,195]

Ulcerations caused by EVS occur in 50% to 78% of patients[196,197] but may be more common if treatments are conducted in closely timed (<1 week) sessions.[198,199] $H_2$ receptor antagonists, proton pump inhibitors, and sucralfate do not prevent ulcer formation,[200-202] but omeprazole may be effective in healing these ulcerations.[203,204] Significant immediate bleeding occurs in 6% of patients[196] and can often be controlled by local endoscopic techniques.[205] Significant delayed bleeding in 19% to 24% of patients can be caused by recurrent variceal bleeding,[206,207] ulceration, or esophagitis.[205] Intramural hematoma has been reported in as many as 1.6% of patients and usually resolves spontaneously.[208]

Esophageal stricture formation occurs in as many as 20% of patients.[209,210] The rate of stricture formation may correlate with the number of EVS sessions and the amount of sclerosant used.[211] Esophageal perforation occurs in 0.5% to 5% of patients after EVS.[208,212,213] Conservative management of localized perforations has been reported,[214] but free perforations carry a poor prognosis in this patient group.[213,215] Aspiration pneumonia has been reported in as many as 5% of patients after EVS and usually occurs during emergent sessions for variceal bleeding.[210,211,216]

EVS may cause extension of thrombus into the portal and mesenteric venous systems, resulting in mesenteric or splenic infarction.[217,218] Cyanoacrylate injection in particular has been reported to cause systemic emboli to the lung, spleen, and portal vein.[219,220]

Bacterial infections occur in as many as 50% of cirrhotic patients admitted with GI hemorrhage of any etiology.[221] EVS may further increase the risk of bacteremia in actively bleeding patients.[222,223] Prophylactic antibiotics are recommended for actively bleeding cirrhotic patients, but not for elective variceal sclerotherapy.[20,221]

**Endoscopic band ligation (EBL).** Endoscopic band ligation is associated with lower rates of adverse events and mortality than EVS.[194,224] Esophageal ulcer formation with EBL is reported in 5% to 15% of patients,[210,216,224,225] Proton pump inhibitors have been shown to facilitate healing of EBL ulcers.[226] Perforation is extremely rare and is usually associated with use of an overtube to assist multiple endoscope passes.[210,216,224] Overtube use for EBL is discouraged. Esophageal stricture formation as a consequence of EBL is rare. No strictures were reported in multiple randomized trials,[210,216,224,225] but a few cases have been reported.[227] Aspiration pneumonia and bacterial peritonitis after EBL have been reported in approximately 1% and 4% of patients, respectively.[210,216,224,225]

## Endoscopic nonvariceal hemostasis

The overall incidence of major adverse events associated with endoscopic nonvariceal hemostasis (ie, perforation and exacerbation of bleeding) is less than 0.5%.[228-230] Injection hemostasis with cyanoacrylate, polidocanol, ethanol, or thrombin has been rarely reported to cause focal tissue necrosis, perforation,[231,232] or exacerbation of bleeding.[233] Randomized, controlled trials using multipolar electrocautery or heater probe have reported rates of perforation as high as 2%.[234-237] The rate of perforation may be higher (≤4%) with repeat heater probe treatment when performed within 24 to 48 hours of the initial session.[238] Induction or exacerbation of bleeding is a relatively common adverse event of thermal hemostasis, occurring in as many as 5% of cases.[229,235,236,239] Although dual therapy with both epinephrine and a thermal modality or with 2 types of injectates is as effective as monotherapy with either a thermal technique or endoscopic clips, adverse events may be higher with dual therapy.[229,235]

Endoscopic clips are the most commonly used mechanical device for endoscopic hemostasis. There have been no significant procedure-related adverse events associated with the use of endoscopic clips in clinical trials.[229,237,240]

## ENDOSCOPIC MANAGEMENT OF ADVERSE EVENTS OF ENDOLUMINAL THERAPY

Many of the adverse events associated with endoluminal therapy can be treated endoscopically. Bleeding can be controlled with injection hemostasis, APC, hemostatic graspers, or endoscopic clips.[147,148,241] The risk of delayed bleeding after EMR may be reduced by prophylactic closure of mucosal defects with endoscopic clips.[142,242] High-dose proton pump inhibitor therapy improves ulcer healing rates and reduces the risk of delayed bleeding after ESD.[148]

Perforation caused by EMR or ESD may be managed by application of endoscopic clips and conservative measures, if identified during the initial procedure.[143,243] Perforations through a neoplasm or at a site of significant inflammation may not be amenable to endoscopic clip closure and may require surgical attention. Rare cases of delayed perforation requiring surgical management have been reported after ESD.[148] EMR of ulcerated lesions or lesions that do not lift adequately with submucosal injection may have a higher risk of perforation.[244] Strictures resulting from endoluminal therapy can be treated with bougies or balloon dilators[147,148,156,158,161] but may require multiple frequent sessions for complete resolution of symptoms.

## ADVERSE EVENTS OF SMALL-BOWEL ENTEROSCOPY

Deep enteroscopy using techniques such as double-balloon enteroscopy (DBE), single-balloon enteroscopy, or spiral enteroscopy have the potential for unique adverse events. Most data stem from DBE studies. A recent meta-analysis found major adverse events in 0.7% of 9047 DBE procedures, including perforation (n = 20), pancreatitis (n = 17), aspiration pneumonia (n = 8), bleeding (n = 6), and 1 death.[245] Minor adverse events were reported in 9.1% of 2017 procedures. The adverse event rate is higher for therapeutic DBE (4.3%) than for diagnostic DBE (0.8%),[246] and perforation is more likely to occur in patients with altered surgical anatomy.[247] The rate of bleeding or perforation may be as high as 10.8% for patients undergoing polypectomy during DBE.[245] Self-limited abdominal pain has been reported in as many as 20% of patients.[248] Pancreatitis is a relatively unique adverse event of balloon enteroscopy, occurring in 0.49%.[245] The pathogenesis of acute pancreatitis caused by DBE has not been determined, but it may be a result of direct trauma to the pancreas or balloon insufflation in the region of the ampulla.

## CONCLUSIONS

Adverse events are inherent in the performance of UGI endoscopic procedures. Because endoscopy assumes a more therapeutic role in the management of GI disorders, the potential for adverse events will likely increase. Knowledge of potential endoscopic adverse events, their expected frequency, and the risk factors for their occurrence may help to minimize the incidence of adverse events. Endoscopists are expected to carefully select patients for the appropriate intervention, be familiar with the planned procedure and available technology, and be prepared to manage any adverse events that may arise. Once an adverse event occurs, early recognition and prompt intervention may minimize the morbidity and mortality associated with that adverse event. Review of adverse events as part of a continuing quality improvement process may serve to educate endoscopists, help to reduce the risk of future adverse events, and improve the overall quality of endoscopy.[249]

## DISCLOSURE

*All authors disclosed no financial relationships relevant to this publication.*

*Abbreviations: APC, argon plasma coagulation; ASGE, American Society for Gastrointestinal Endoscopy; DBE, double-balloon enteroscopy; EBL, endoscopic band ligation; ESD, endoscopic submucosal dissection; EVS, endoscopic variceal sclerotherapy; PDT, photodynamic therapy; RFA, radiofrequency ablation; SEMS, self-expandable metal stents; UGI, upper GI.*

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