Introduction

Gut perforations during ERCP and stenting or due to migration of stents are very rare complications, with an incidence of well below 2%. Moreover, direct duodenoscope-induced lateral or medial duodenal wall perforation is much less common, accounting for 0.1% of patients who undergo ERCP, but tends to be large and further away from the ampulla.1-6 Duodenal perforations from the superior duodenal angle to the descending duodenum may be complicated by leakage of digestive enzymes from the pancreas, which may severely damage other organs. Accordingly duodenal wall perforation is one of the most feared complications of ERCP.

Traditionally, the standard treatment for traumatic or iatrogenic duodenal perforation is early surgical closure because of a relatively high mortality rate of 16%-18%.1-4 However, although ERCP-related lateral or medial duodenal wall perforations usually require immediate surgery, there are inoperable cases because of advanced patient age and combined comorbidities that prohibit surgical treatment. When nonoperative management of a large lateral or medial duodenal perforation is selected, early closure of the perforation is essential.

Recently, numerous endoscopic trials of perforation management have increased and successful primary repair of duodenal perforation using the endoscope itself has been reported.1-5 However, till now the best therapeutic option of these complications remains a matter of debate.

Types of iatrogenic duodenal perforations

Several researchers have classified ERCP-related perforations according to injury location or mechanism and have proposed treatment recommendations. Stapfer et al.1 classified perforations into four types, in decreasing order of severity, with implications for management. Type I perforations are perforations of the lateral or medial wall of the duodenum with large size and remote from the ampulla, and are caused by the endoscope itself or by the stent. These perforations cause considerable spillage, either retroperitoneally or intraperitoneally, necessitating aggressive surgical intervention. Type II perforations are perforations of the medial wall of the duodenum, peri-Vaterian, are generally retroperitoneal, and are caused during sphincterotomies. These tend to lend themselves to conservative or minimally invasive management. Type III injuries are distal bile duct injuries caused by instrumentation and/or stenting in the proximity of an obstruction. These perforations are small and
amenable to conservative management. Type IV perforations are tiny retroperitoneal perforations caused by the use of compressed air during endoscopy and can be managed conservatively. Howard et al.\textsuperscript{2} classified perforations into three types according to the mechanism of injury. Group I refers to guidewire-induced perforations, group II to periampullary, and group III to duodenal perforations. Group III needs immediate surgery. Enns et al.\textsuperscript{3} classified three categories. Esophageal, gastric, and duodenal perforation which need a surgical management. Sphincterotomy-related perforation or guidewire-related perforation needs conservative management mostly.

**Clinical features**

Known risk factors of an ERCP-related perforation might include old age, suspected sphincter of Oddi dysfunction, dilated bile duct, papillary stenosis, Billroth-\textsuperscript{II} reconstruction, precut sphincterotomy, and long procedure duration.\textsuperscript{7-9} The classic presentation of duodenal perforation, with severe epigastric pain, vomiting, and epigastric tenderness progressing to generalized board-like rigidity, is only seen in a minority of cases. The symptoms and signs of ERCP-related perforations are often mild when this complication is recognized early.\textsuperscript{1,10-12} So, initially the clinical presentation of patients with perforation is non-specific. Duodenal perforation secondary to placement of a biliary endoprosthesis should be considered in all patients presenting with abdominal pain after such a placement. Early clinical suspicion and diagnosis of a procedure-related perforation can be facilitated greatly by clinical findings and especially radiographic imaging with contrast studies, CT, and even magnetic resonance imaging. A multi-slice CT scan can provide an exact diagnosis of this complication.

**Endoscopic managements of duodenal free wall perforations**

Type I [lateral or medial wall duodenal perforation; Stapfer et al.\textsuperscript{1}] or Group III [duodenal perforation remote from the papilla; Howard et al.\textsuperscript{2}] injuries are usually large and traditionally require immediate surgery for repair. In a study by Stapfer et al.\textsuperscript{1}, surgery was recommended for patients with the following criteria: large contrast extravasation on ERCP/UGIs, contrast-enhanced CT scans showing intra- or retroperitoneal fluid collection, massive subcutaneous emphysema or suspected perforation in association with retained material (i.e. stones, ERCP wire/basket). In cases of peri-Vaterian injuries, they suggested conservative management with serial radiographic examination. Howard et al.\textsuperscript{2} also suggested the use of endoscopic drainage to divert the bile, pancreatic, and/or duodenal fluids away from the perforation, and showed that the endoscopic approach reduced the rates of surgery, mortality, and length of hospital stay. However, unlike more common spontaneous perforation resulting from peptic ulcer disease, endoscopic therapy-related iatrogenic perforations have a relatively lower chance of bacterial contamination in a fasting state, and there is therefore sometimes an opportunity to manage these patients using nonsurgical means such as endoscopic therapies. A small amount of bacterial contamination may be controlled by the administration of antibiotics and conservative management.\textsuperscript{13}

Recently, trials of endoscopic management have been performed and suggested. There have been sporadic reports about the use of an endoscopic clipping device for the closure of iatrogenic perforations during endoscopic mucosal resection (EMR) or sphincterotomy in the esophagus, stomach, and duodenum.\textsuperscript{14-19} Though
surgery remains the standard treatment for duodenal perforations caused by the endoscope itself, the outcomes from case reports support the beneficial role of endoclips in the closure of these defects.\textsuperscript{5,20-22} In particular, some reports described that nonsurgical treatment is possible for the perforation of the upper gastrointestinal tract when peritonitis remains localized. The clinician’s familiarity with endoclips and their immediate availability and proper use may avoid surgery for a selected group of patients with a high surgical risk.

However, usual primary endoscopic closure by endoclips may be difficult due to the position of the lateral wall and the complexity of aligning the perforation with the endoscope. To approximate the perforated hole and adherent hemoclips, glue injection and sprayings may be successfully performed under cap-fitted endoscopy.\textsuperscript{18,20} Glue injection may adherent multiple clips and provide a cushion effect below the base of perforation. Also, since clipping with a duodenoscopy can be technically difficult, a cap-assisted, forward-view endoscopy can be used effectively. Second, endoscopic repair using endoclips can be limited in large perforations or in those with tangential angles. A wide perforation is difficult to close because of slippage of the perforation edge from the clip while the clip is maneuvered across the defect to grasp the opposite edge of the perforation. Everted perforation edges also make it impossible to grasp the tissue with endoclips. As a modified method except additional glue injection, endoscopic closure by using endoloops with endoclips showed good clinical result even though case reports.\textsuperscript{23-25} Clinical trials using an endoloop and multiple hemoclips to cover large mucosal defects following ESD or ERCP-induced perforation have been performed.\textsuperscript{23-28} Following placement of endoloop around the perforated area through one-channel or two-channel endoscopy, multiple clips are attached with the endoloop to the perforated area and then finally the endoloop is tightened and this closes the perforated area.\textsuperscript{29}

Recent studies have reported high technical success rates for primary closure of an acute iatrogenic perforation with newly developed devices.\textsuperscript{5,13-15} These devices include through-the-scope (TTS) clips, such as the QuickClip 2 (Olympus Inc., Center Valley, PA, United States), the Resolution clip (Boston Scientific Inc., Natick, MA, United States), and the Tri-Clip and Instinct clip (Cook Medical, Winston-Salem, NC, United States); the over-the-scope clip (OTSC) system (Ovesco Endoscopy AG, Tubingen, Germany); and endoscopic suturing devices such as T-tags (Ethicon Endo-Surgery, Cincinnati, OH, United States) and the flexible Endo Stitch (Covidien, Mansfield, MA, United States). Closure of luminal perforation > 20 mm in size may be difficult. For larger gastric defects, TTS clips can be placed around the circumference of the perforation and lassoed together with a detachable plastic snare (Endo-loop; Olympus). Among the newly developed devices, OTSC was approved for the closure of perforation < 20 mm in size, and ex vivo studies shown that colon defects 10 to 30 mm in size can be closed with a single OTSC.\textsuperscript{16} However, although some techniques have been developed to correct deficits in clip placement, they are not commonly practiced. Some of these devices may prove suitable for the closure of defects throughout the intestinal tract, but their use is limited by the endoscopist’s experience, device availability, and cost. Currently, no particular technique has demonstrated proven efficacy or greater reliability than other closure modalities.

Technically, EBL is a simple procedure to treat bleeding from esophageal varices. The simplicity of the technique and low complication rates compared with sclerotherapy have contributed to its growing popularity.\textsuperscript{5} EBL has been also widely used in the management of non-variceal hemorrhage from Dieulafoy’s ulcer, gastric angiodysplasia, and polypectomy-induced bleeding. In addition, several reports have described the use of EBL in rectal and duodenal perforations during EMR. Theoretically, EBL can readily approximate both edges of the
perforation. Thus, complete suture to the remaining wall by additional bands or endoclips may be simple, even with a large perforation.\(^1\) EBL can also reduce procedure time in comparison with clipping. Immediate closure could prevent the need for surgery or the development of serious peritonitis caused by gastric content leakage. Finally, the use of additional clips to suture the perforation after EBL might not be necessary. Accordingly, EBL may be also adapted in duodenoscope-induced duodenal wall perforation. However, more experimental studies are needed to confirm it.

**Conclusions**

Traditionally, the standard treatment for traumatic or iatrogenic duodenal perforation is surgical closure. Recently, endoscopic trials of perforation management have increased and successful primary repair of duodenal perforation using the endoscope itself has been reported. However, there is no clear consensus for primary repair due to the limited number of cases seen. Although the surgical operation remains the standard treatment for duodenal perforation, several reports support the use of endoscopic closure of the perforation with conservative treatments for selected cases of the injury caused by the endoscope itself. As an improvement of endoscopic devices, endoscopic treatment may replace the role of surgical management in near future.

**References**