Endoscopic ultrasound-directed transgastric ERCP (EDGE): a retrospective multicenter study

Authors
Thomas M. Runge¹, Austin L. Chiang², Thomas E. Kowalski², Theodore W. James³, Todd H. Baron³, Jose Nieto⁴, David L. Diehl⁵, Matthew R. Krafft⁶, John Y. Nasr⁶, Vikas Kumar⁵, Harshit S. Khara⁵, Shayan Irani⁵, Arpan Patel⁷, Ryan J. Law⁸, David E. Loren², Alex Schlachterman², William Hsueh⁹, Bradley D. Confer³, Tyler K. Stevens⁹, Prabhleen Chahal⁹, Mohammad A. Al-Haddad¹⁰, Fahad Faisal Mir¹¹, Douglas K. Pleskow¹¹, Matthew T. Huggett¹², Bharat Paranandi¹², Arvind J. Trindade¹³, Olaya I. Brewer-Gutierrezⁱ, Yervant Ichkhanianⁱ, Mohamad Dbouk¹, Vivek Kumbhari¹, Mouen A. Khashab¹

Institutions
1 Division of Gastroenterology and Hepatology, The Johns Hopkins Medical Institutions, Baltimore, Maryland, USA
2 Division of Gastroenterology and Hepatology, Thomas Jefferson University Hospital, Philadelphia, Pennsylvania, USA
3 Division of Gastroenterology and Hepatology, University of North Carolina Hospitals, Chapel Hill, North Carolina, USA
4 Borland Groover Clinic, Advanced Therapeutic Endoscopy Center, Jacksonville, Florida, USA
5 Department of Gastroenterology, Geisinger Medical Center, Danville, Pennsylvania, USA
6 Section of Digestive Diseases, Department of Medicine, West Virginia University, Morgantown West Virginia, USA
7 Digestive Disease Institute, Virginia Mason Medical Center, Seattle, Washington, USA
8 Division of Gastroenterology and Hepatology, University of Michigan, Ann Arbor, Michigan, USA
9 Department of Gastroenterology and Hepatology, Cleveland Clinic Foundation, Cleveland, Ohio, USA
10 Division of Gastroenterology, Indiana School of Medicine, Indianapolis, Indiana, USA
11 Division of Gastroenterology, Department of Medicine, Beth Israel Deaconess Medical Center, Boston, Massachusetts, USA
12 Department of Gastroenterology, St. James’ University Hospital, Leeds, UK
13 Zucker School of Medicine at Hofstra/Northwell, Long Island Jewish Medical Center, Northwell Health, New Hyde Park, New York, USA

Submitted 29.5.2020
Accepted after revision 3.9.2020
Published online 3.9.2020

ABSTRACT
Background Endoscopic ultrasound-directed transgastric endoscopic retrograde cholangiopancreatography (ERCP; EDGE) is an alternative to enteroscopy- and laparoscopy-assisted ERCP in patients with Roux-en-Y gastric bypass anatomy. Although short-term results are promising, the long-term outcomes are not known. The aims of this study were: (1) to determine the rates of long-term adverse events after EDGE, with a focus on rates of persistent gastrogastric or jejunogastric fistula; (2) to identify predictors of persistent fistula; (3) to assess the outcomes of endoscopic closure when persistent fistula is encountered.

Methods This was a multicenter retrospective study involving 13 centers between February 2015 and March 2019. Adverse events were defined according to the ASGE lexicon. Persistent fistula was defined as an upper gastrointestinal series or esophagogastroduodenoscopy showing evidence of fistula.

Results 178 patients (mean age 58 years, 79% women) underwent EDGE. Technical success was achieved in 98% of cases (175/178), with a mean procedure time of 92 minutes. Periprocedural adverse events occurred in 28 patients (15.7%; mild 10.1%, moderate 3.4%, severe 2.2%). The four severe adverse events were managed laparoscopically. Persistent fistula was diagnosed in 10% of those sent for objective testing (9/90). Following identification of a fistula, 5/9...
Introduction

Obesity remains a central public health issue, with rising prevalence in the USA and worldwide [1, 2]. Roux-en-Y gastric bypass (RYGB) is a common and highly successful surgical treatment for obesity and its associated medical co-morbidities [3–5]. Patients undergoing RYGB have higher rates of gallstone disease [6, 7] and may require endoscopic retrograde cholangiopancreatography (ERCP) to manage bile duct stones or other pancreatobiliary issues. However, endoscopic access to the biliary tree after RYGB is challenging. Conventional ERCP methods include balloon-assisted enteroscopy (BAE-ERCP) or laparoscopy-assisted ERCP (LA-ERCP) [8–10]. BAE-ERCP is limited by suboptimal technical success rates that range from 50%–70% [8, 9, 11]. LA-ERCP is highly efficacious, but may require conversion to open laparotomy in 5%–13% of cases [9, 12].

There is no consensus as to the preferred approach to ERCP after RYGB.

Recently, endoscopic ultrasound (EUS)-directed transgastric ERCP (EDGE) has emerged as an option for ERCP after RYGB [10, 13–16]. This technique involves the creation of a temporary transgastric fistula by placing a lumen-apposing metal stent (LAMS) that connects either the gastric pouch or the proximal jejunum to the excluded stomach (▶ Fig. 1). The LAMS creates a stable connection to the excluded stomach, facilitating antegrade ERCP across the new tract. The advantages of EDGE include its high success rate [10, 14], the avoidance of surgery, and procedure completion entirely within the endoscopy suite, potentially reducing hospital length of stay (LOS) [17].

The current literature on EDGE is limited. Published studies have included 30 or fewer patients and long-term follow-up data are scant. Specifically, the rates of persistent gastrogastric fistula or jejunogastric fistula are unknown. The aim of this study was to assess the short-term and long-term outcomes following EDGE, with an emphasis on the rates of persistent gastrogastric and jejunogastric fistulas.

Methods

We conducted an international, multicenter retrospective cohort study of consecutive patients with a history of RYGB who underwent EDGE at 13 tertiary care centers (12 US centers, 1 European center) between February 2015 and March 2019. Endoscopists at each center had extensive expertise in pancreaticobiliary endoscopy and interventional EUS.

All patients underwent EUS-gastrogastrotomy (EUS-GG) or jejunogastrotomy (EUS-JG) for ERCP access. Patients undergoing EUS-GG or EUS-JG for indications other than ERCP were excluded. Although 65 patients had been previously reported [10, 17–19], those studies were not designed to assess the frequency of or treatment options for persistent fistulas following EDGE. The present study was approved by the Institutional Review Boards and complied with Health Insurance Portability and

Conclusions

The EDGE procedure is associated with high clinical success rates and an acceptable risk profile. Persistent fistulas after lumen-apposing stent removal are uncommon, but objective testing is recommended to identify their presence. When persistent fistulas are identified, endoscopic treatment is warranted, and should be successful in closing the fistula.

Fig. 1 Diagrams depicting: a the upper gastrointestinal tract anatomy following Roux-en-Y gastric bypass; b, c the location of the transgastric lumen-apposing metal stent (LAMS) and the path of the endoscope after: b gastrogastric stent placement; c jejunogastric stent placement.
then ERCP on the same day) or in two sessions (LAMS at the first 15–20 mm.

deter EUS and fluoroscopic guidance, which was followed by de-
ployment of the needle before further contrast/saline was in-
jected to distend the stomach.

If placement of a non-cautery tip LAMS was planned, wire placement and dilation were performed to facilitate LAMS deployment. In this procedure, a 0.025-inch biliary guidewire (VisiGlide; Olympus) was advanced through the needle and coiled within the stomach. The fistula tract was typically dilated with a 6-mm biliary balloon dilator. Following tract dilation, the LAMS delivery catheter (AXIOS; Boston Scientific, Marlborough, Massachusetts, USA) was advanced over the wire into the ex-
cluded stomach, and deployed (Fig. 1s, see online-only Supplementary Material). The choice of gastrogastric or jejunogastric puncture was made at the time of the procedure by the endos-
copist performing the procedure. When an electrocautery-en-
hanced LAMS was used, the stent could be deployed either over a guidewire or “freehand,” at the discretion of the endos-
copist. Once the excluded stomach had been accessed with the LAMS catheter, the distal flange of the stent was deployed un-
der EUS and fluoroscopic guidance, which was followed by de-
ployment of the proximal flange. The LAMS used had a diame-
ter of 15 or 20 mm.

Initial EDGE was performed either in a single session (LAMS then ERCP on the same day) or in two sessions (LAMS at the first procedure, with ERCP at a later date). For single-session EDGE, the stent lumen was dilated to 15–20 mm with a balloon dilator before ERCP. For two-stage procedures, dilation was performed at the discretion of the endoscopist. Stent fixation techniques (clips, over-the-scope [OTS] clips, or endoscopic suturing) were performed at the discretion of the endoscopists for single-
session EDGE (Fig. 2s).

Transgastric ERCP and follow-up

Following fistula creation, either a therapeutic duodenoscope (TJF-Q180V; Olympus) or a slim duodenoscope (JF-Q140V, JF-
Q160V, or JF-Q180V; Olympus) was advanced across the LAMS into the excluded stomach and ultimately into the second por-
tion of the duodenum for completion of the intended biliary or pancreatic therapies (Fig. 3s). If multiple ERCP sessions were required, the gastrogastric or jejunogastric fistula tract was kept open with the transgastric stent. When access was no longer needed, the LAMS was removed with grasping forceps or a snare. If only a single ERCP was needed, LAMS removal was done after 4 weeks (two procedures in total).

After the LAMS had been removed, the fistula tract was managed at the discretion of the performing endoscopist and included no therapy, argon plasma coagulation (APC) applied to the tract, or closure of the fistula edges by endoscopic clip closure, OTS clipping, or endoscopic suturing. Fistula closure after removal of the LAMS was confirmed either by upper gas-
trointestinal (GI) endoscopy, upper GI series, or cross-sectional imaging, with closure defined as no contrast entry into the ex-
cluded stomach, or lack of an endoscopically visible opening.

Study outcomes and definitions

The primary outcome of the study was the technical success of EDGE, defined as successful placement of a transmural LAMS followed by ERCP with cannulation of the intended duct and completion of the intended intervention(s). Secondary outcomes included: short-term adverse events, rates of persistent gastrogastric and jejunogastric fistulas, efficacy and clinical outcomes following endoscopic closure of persistent fistulas, sizes of persistent fistulas, and rates of refractory fistulas. Other procedure-related data, such as procedure time, hospital LOS, and stent dwell time, were also collected.

A persistent fistula was defined as objective evidence (via radiologic study and/or endoscopy) of an ongoing fistula at least 8 weeks after LAMS removal. A refractory fistula was de-

Statistical analysis

Statistical analysis was performed with Stata software, version 13 (StataCorp, College Station, Texas, USA). Results were re-
ported as mean (standard deviation [SD]), median (interquar-
tile range [IQR]), and percentage for categorical variables. De-
scriptive statistics were used to summarize the data, and bivari-
ate analyses were performed using the Student’s t test, chi-
squared test, or Fisher’s exact test where appropriate. Specifi-
cally, Student’s t test was used to compare the rates of persist-
ent fistula following gastrogastric or jejunogastric LAMS, and in comparisons of mean Charlson comorbidity index (CCI), stent dwell time, and presence of diabetes for cases with/without persistent fistula. Fisher’s exact test was used to compare out-
comes across centers (Table 1s). The threshold for statistical significance (α) was set at a two-sided P value of 0.05.

Results

Patient and procedure characteristics

A total of 178 patients who underwent attempted EDGE were identified. The mean age of the patients was 58 (SD 11) years, and 79% were women (Table 1). There were 44 patients (25
%) who had diabetes mellitus, while 32 (18 %) and 20 (11 %) used tobacco and had a history of CAD, respectively. A minority of

Accountability Act (HIPAA) regulations [20] at each participat-
ing center.

Procedure techniques

**EUS-guided LAMS placement**

General anesthesia with endotracheal intubation was used in all patients. A therapeutic linear echoendoscope (GF-UCT180; Olympus, Center Valley, Pennsylvania, USA) was used to identi-
fy the excluded stomach from either the gastric pouch or the proximal Roux limb. Doppler imaging was used to avoid inter-
vening vessels. The excluded stomach was punctured with a 19-gauge fine-needle aspiration (FNA) needle. Contrast was in-
jected under fluoroscopic and EUS guidance to confirm correct placement of the needle before further contrast/saline was in-
jected to distend the stomach.

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patients presented with cholangitis (8%) or had failed endoscopy prior to EDGE (13%).

EUS-guided LAMS placement was successful in 175/178 patients (technical success 98%) (Fig. 2). ERCP was successfully completed in all patients who underwent successful LAMS placement (175/175; 100%) (Fig. 2). Therefore, the technical success of EDGE was 175/178 (98% overall). The number of patients per center is listed in Table 1. There was no significant difference in the technical success of EDGE across centers.

A total of 88 patients (50.2%) underwent EUS-GG, and 87 patients (49.7%) underwent EUS-JG creation. The majority of procedures were performed using a cautery-assisted LAMS (92% [164/178]).

Three patients had failed EUS-LAMS placement. In the first of these, the LAMS misdeployed distally. The gastric perforation was explored and the LAMS was identified entering the excluded stomach. A fully covered esophageal stent was placed across the tract, but ultimately the patient required surgical intervention. In the other two patients, the distal flange was inadvertently drawn back into the gastric pouch. One of these patients had an esophageal stent placed across the transgastric tract and the procedure was aborted without the ERCP being performed. In the other patient, the LAMS was removed and the pouch perforation was closed with an OTS clip. The patient ultimately did not require surgery but, at the time of data collection, definitive therapy for choleodocholithiasis had not occurred.

EDGE procedures were completed in a mean time of 92 (SD 47) minutes, with 49% completed in a single session. A 15-mm stent was more commonly used than the newer 20-mm stent (112 [63%] vs. 66 [37%], respectively). The LAMS was secured in 18% of patients (32/178), using an endoscopic suturing system in 29/32 procedures (91%), through-the-scope (TTS) clips in two procedures, and OTS clips in one procedure (Table 2). The median length of hospital stay post-procedure was 0 days (IQR 0–4). The mean follow-up time post-procedure was 5.5 (SD 6) months.

When pancreaticobiliary access was no longer required, the LAMS was removed. At the time of data collection for this study, stent removal had been performed in 153/175 EDGE patients (87%) after a median of 35 days (IQR 22–54). Following LAMS removal, the gastrogastric or jejunogastric fistula was managed as follows: no treatment in 20% of patients (n = 31), and APC alone in 36% of cases (n = 55). Endoscopically complete closure of the fistula was performed with endoscopic suturing in 37% (n = 57), TTS clips in 5% (n = 7) and OTSC in 2% (n = 3) (Table 3).

### Adverse events

There were a total of 28 early adverse events (15.7%) (Table 4). Across centers, there was no statistically significant difference in the adverse event rates (Table 1). Perforation occurred

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**Table 1** Baseline characteristics of the 178 patients who underwent endoscopic ultrasound-directed transgastric endoscopic retrograde cholangiopancreatography (EDGE).

<table>
<thead>
<tr>
<th>Demographic data</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean (SD), years</td>
<td>58 (11)</td>
</tr>
<tr>
<td>Sex, female, n (%)</td>
<td>140 (79)</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td>44 (25)</td>
</tr>
<tr>
<td>Coronary artery disease, n (%)</td>
<td>20 (11)</td>
</tr>
<tr>
<td>Tobacco use, n (%)</td>
<td>32 (18)</td>
</tr>
<tr>
<td>Cholangitis at time of ERCP, n (%)</td>
<td>15 (8)</td>
</tr>
<tr>
<td>Prior failed endoscopy-assisted ERCP, n (%)</td>
<td>23 (13)</td>
</tr>
</tbody>
</table>

**Indication for ERCP, n (%)**

- Cholecodocholithiasis 97 (54)
- Bile leak 18 (10)
- Benign biliary stricture 16 (9)
- Recurrent acute pancreatitis 12 (7)
- Malignant biliary stricture 8 (4)
- Abnormal imaging study 8 (4)
- Pancreatic duct stone 4 (2)
- For cholangioscopy NOS 2 (1)
- Chronic pancreatitis NOS 1 (1)
- Other, n (%)* 12 (7)

SD, standard deviation; ERCP, endoscopic retrograde cholangiopancreatography; NOS, not otherwise specified.

* Including retained foreign body and sphincter of Oddi (SOD) dysfunction types 1/2.
in six patients (3%), five of which occurred during EUS-guided transgastric (n = 1) or transjejunal (n = 4) stent placement, and there was one sphincterotomy-associated perforation that occurred during ERCP. Five perforations were managed with endoscopic closure (n = 4) or conservative measures, including nasogastric tube placement, bowel rest, and intravenous antibiotics (n = 1); one patient required surgery to treat a perforation. Symptomatic capnoperitoneum occurred in three patients (1.5%), requiring laparoscopic decompression in two patients and percutaneous needle decompression in one. In both cases where surgical decompression was performed, the consulting surgical team performed diagnostic laparoscopy to assess for perforation or leak. When none was found, the abdomen was decompressed via laparoscopy.

Intraprocedural LAMS migration occurred in two patients (1.1%). In both of these patients, EDGE was aborted and not reattempted; these patients are included in the three failed EUS cases. Misdeployment of the LAMS requiring management prior to EDGE completion occurred in nine patients (5%). In all cases this was managed with placement of a bridging esophageal stent or a second LAMS, allowing completion of the procedures.

Other adverse events included: procedure-related bleeding requiring transfusion in two patients (1.1%), delayed stent migration in two patients (1.1%), post-ERCP pancreatitis in three patients (1.7%), and cholangitis due to ERCP in one patient (0.6%). Adverse events were rated severe in four patients (2.2%), moderate in six (3.4%), and mild in 18 (10.1%).

### Persistent fistula

#### Characteristics and predictive factors

A total of 90 patients (59% of those who underwent LAMS removal) were tested for persistent fistula following LAMS placement. Nine patients (10% of those tested) were found to have a persistent fistula at least 8 weeks after LAMS removal. The clinical characteristics and outcomes of the patients with persistent fistulas are summarized in Table 2.

There was no statistically significant difference between the rate of persistent fistula following placement of a gastric LAMS (9% [4/45 patients]) vs. jejunal LAMS (11% [5/45]; P = 0.73). On bivariate analysis, there were trends toward longer median stent dwell time for persistent fistula (50 days vs. 34 days; P = 0.09) and higher mean CCI score (2.6 [SD 1.5] vs. 1.5 [SD 1.8]; P = 0.10), but these differences did not reach statistical significance. None of the nine patients with persistent fistula underwent any attempted fistula closure at LAMS removal (APC alone or no therapy was performed in all of these patients).

On bivariate analysis, diabetes mellitus was significantly more common in those who developed persistent fistula than in those who did not (56% vs. 21%; P = 0.02).

#### Weight changes, endoscopic closure, and clinical outcomes

Nine patients were found to have a persistent fistula following EDGE. One patient declined any further intervention and one underwent surgery for severe chronic pancreatitis, and the excluded stomach was resected at that time. In two cases, the patients had not yet returned for follow-up at the time of data collection (Table 2). Five patients underwent endoscopic therapy for persistent fistula, which was successful in all cases after one (n = 3) or two (n = 2) endoscopic procedures. All five patients had confirmation of fistula closure by objective testing. There were no adverse events associated with endoscopic fistula closure in any patient who underwent these procedures.

Weight changes for patients with a persistent fistula and those who did not are shown in Table 2. Of the nine patients with persistent fistula, only one (11%) gained weight during the study period, with three patients gaining weight during the study.
Discussion

Endoscopists face a formidable challenge when managing pancreaticobiliary disease in RYGB patients. Currently, there is no accepted first-line modality to be performed in patients who have undergone prior gastric bypass.

Some centers have embraced the highly efficacious LA-ERCP as a first-line approach, with efficacy rates near 100% in several published studies [12, 24–26]. However, LA-ERCP has multiple downsides including complicated logistics, operating room costs, and laparoscopy-associated adverse events, including the possible need for open surgery [9, 12, 26]. LA-ERCP is not ideal if there is a need for additional ERCPs. In the largest published cohort to date, Abbas et al. found that >15% of patients were left with a percutaneous endoscopic gastrostomy (PEG) tube in place owing to the need for a repeat procedure [12]; other studies have reported the need for a PEG for future access in up to 44% of patients [24]. With a majority of adverse events associated with LA-ERCP arising from the laparoscopy, the potential need for repeat access [12, 24, 25], and with patients increasingly seeking minimally invasive and endoscopic therapies [27, 28], the need for an effective endoscopic approach to ERCP following RYGB is clear.

Single-balloon or double-balloon enteroscopy have historically been the initial technique offered. Advantages include the avoidance of surgical intervention and lower costs compared with LA-ERCP [8, 9]. However, success rates range from 60% to 88% [8–10, 29–31], compared with efficacy rates of 98%–100% in the published literature on LA-ERCP [8, 9, 12, 25, 29]. Even with relatively low complication rates, low rates of successful BAE-ERCP make this procedure difficult to justify.

EDGE, first described 5 years ago [32], bridges the gap between balloon-assisted endoscopic procedures and the more invasive LA-ERCP (Fig. 1). In this large multicenter study, we found that EDGE was successful in 98% of cases, comparable to rates of 97%–100% in the existing literature [10, 16, 17, 19]. There were 28 early adverse events that occurred following EDGE (15.7% of all cases), with 22 events attributable to the EUS access and six attributable to the ERCP. Events attributable to ERCP (n = 6) were mild (n = 3) or moderate (n = 3) in severity, according to the ASGE lexicon. Events attributable to EUS (n = 22) were predominantly mild (n = 15) or moderate (n = 3) in severity, although there were four severe events, three of which involved laparoscopic intervention and one of which involved a prolonged hospital stay following the procedure. These rates are comparable with those found in the existing literature.

This study focused on the frequency and management of post-EDGE fistulas, given the extremely sparse data on this topic [10, 17, 19]. We report 90 patients who underwent objective testing for fistula. Persistent fistula was found in nine patients (10% of those tested), consisting of five jejuno gastric fistulas and four gastrogastroscopic fistulas. Not all patients returned for further management of the fistula but, in those who did return, endoscopic closure was successful in all cases.

There is concern regarding the creation of an iatrogenic gastrogastric or jejunogastric fistula for the purposes of performing transgastric ERCP [26, 33–35]. Most worrisome is the theoretical concern that an iatrogenic fistula becomes a chronic fistula that causes weight regain, or precipitates GI symptoms and/or marginal ulcers, with either scenario potentially requiring revisional surgery. However, two pieces of evidence from this study suggest these concerns may be unfounded. First is

<table>
<thead>
<tr>
<th>Table 4 Adverse events following endoscopic ultrasound-directed transgastric endoscopic retrograde cholangiopancreatography (EDGE).</th>
<th>n</th>
<th>Severity*</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perforation</td>
<td>6</td>
<td>Severe (1)</td>
<td>Laparoscopic surgical closure (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Moderate (2)</td>
<td>Closed endoscopically (1) Conservative management (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mild (3)</td>
<td>Closed endoscopically (3)</td>
</tr>
<tr>
<td>Symptomatic pneumoperitonitis</td>
<td>3</td>
<td>Severe (2)</td>
<td>Laparoscopic decompression (2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mild (1)</td>
<td>Needle decompression, no further intervention (1)</td>
</tr>
<tr>
<td>LAMS migration, intraprocedural</td>
<td>2</td>
<td>Severe (1)</td>
<td>Hypotension, intubation, ICU stay (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mild (1)</td>
<td>Procedure aborted (1)</td>
</tr>
<tr>
<td>LAMS misdeployment requiring bridging stent</td>
<td>9</td>
<td>Moderate (1)</td>
<td>Bridging stent placed and procedure completed (9)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mild (8)</td>
<td></td>
</tr>
<tr>
<td>LAMS migration, delayed</td>
<td>2</td>
<td>Mild (2)</td>
<td>No intervention required (2)</td>
</tr>
<tr>
<td>Bleeding requiring red cell transfusion</td>
<td>2</td>
<td>Moderate (2)</td>
<td>Transfusions of 2 units and 3 units; EGD performed, with no active bleeding in either case (2)</td>
</tr>
<tr>
<td>Post-ERCP pancreatitis</td>
<td>3</td>
<td>Mild (3)</td>
<td>Conservative management (3)</td>
</tr>
<tr>
<td>Cholangitis</td>
<td>1</td>
<td>Moderate (1)</td>
<td>Intravenous then oral antibiotics (1)</td>
</tr>
</tbody>
</table>

LAMS, lumen-apposing metal stent; ICU, intensive care unit; EGD, esophagogastroduodenoscopy; ERCP, endoscopic retrograde cholangiopancreatography.

* According to ASGE Lexicon [21].
the age of the fistula. The published literature on patients needing gastrogastric fistula repair describes fistulas present for years (mean 1.4 – 4.8 years post-RYGB) [36 – 38], compared with fistulas in the EDGE subpopulation, which were present for a mean duration of 49 days (1.6 months). Second, the high success of endoscopic closure in this study suggests post-EDGE fistulas are a distinct clinical entity that are more easily managed. In published studies, the clinical success of gastrogastric fistula closure is low, ranging from 0% – 35% [37, 39]. The success of fistula closure in this study argues that wound healing and tissue integrity are not deranged to the same level as is seen in chronic spontaneous fistulas.

The efficacy of EDGE argues that it should be in the discussion as a first-line modality for ERCP in RYGB patients. However, it is important to recognize the strengths and scope of practice of those at each institution who will take care of these patients. In this study, EDGE procedures were performed by endoscopists with expertise in interventional EUS who were comfortable with the placement and management of LAMSs. There are not standardized criteria for assessing “experience” in interventional EUS or LAMS placement, although these tools may be developed in the future. The continued proliferation of LAMSs, especially the newer large-diameter 20-mm stents, could lead to increasing comfort in performing EDGE. These wider stents theoretically would reduce the chance of stent migration during advancement of the duodenoscope. In addition, both OTS clips and endoscopic suturing devices are much more readily available in endoscopy centers, as are those with experience in their use. These devices can be used to fix the LAMS in position to avoid stent migration during ERCP, although duodenoscope advancement must still be performed carefully [40].

One possible barrier to more widespread use of EDGE is the high cost of the LAMS for the procedure. However, it is not only device costs that should be considered with a procedure such as this. Endoscopic options for ERCP in RYGB typically are associated with minimal post-procedural recovery and the absence of post-ERCP pancreatitis. EDGE can be performed entirely on an outpatient basis. In this study, >50% of patients were discharged following the procedure, accruing zero days in the hospital. Mean hospital LOS was 1.6 days (SD 3). These figures compare favorably with LA-ERCP, for which published LOS varies (1.9 – 3.9 days) [12, 17, 24, 25]. In a recent analysis, EDGE was found to be more cost-effective than either LA-ERCP or BAE-ERCP [41], including the cost of the devices used. This advantage of EDGE over either of the other two procedures persisted in >90% of modeling simulations in the study. What is needed next is clearly a prospective comparative trial that can compare the efficacy and cost outcomes for EDGE, LA-ERCP, and BAE-ERCP.

There are several limitations to this study. This was a retrospective study with inherent limitations due to its design. Because of the lack of a standard testing protocol, we have objective follow-up testing for fistulas in only about half of patients who underwent EDGE. Some patients who developed a persistent fistula were likely missed among those who were not tested. However, the figures presented here provide the best estimates thus far of the true prevalence of persistent fistula post-EDGE and will inform sample size calculations for a future prospective study. Another possible limitation of this study is its generalizability. Because procedures in this study were performed by those with specialized expertise in interventional endoscopy, it may be difficult to extrapolate these results to community settings.

In conclusion, EDGE is associated with high clinical success rates and an acceptable risk profile. Persistent fistulas are uncommon, but are detectable 10% of the time after EDGE. Weight trends following EDGE are not a reliable indicator of an underlying fistula. If a persistent fistula occurs after EDGE, our data suggest that this can be readily treated endoscopically, with an excellent clinical outcome. Greater experience in fistula identification and closure in the future will be necessary to draw further conclusions about closure methods at LAMS removal.

Competing interests

A.L. Chang has received consultancy fees and research support from Boston Scientific; T.E. Kowalski has received consultancy fees from Boston Scientific and Medtronic; T.H. Baron has received consultancy fees from Boston Scientific, Cook Endoscopy, W.L. Gore, Medtronic, and Olympus America, and speaker’s fees from Medtronic; J. Nieto has received consultancy fees from Boston Scientific and Olympus America, and speaker’s fees from AbbVie; J.Y. Nasr has received consultancy fees from Boston Scientific; H.S. Khara has received consultancy fees from Boston Scientific and speaker’s fees from Olympus America, Covidien, Gurus ACMi, Inc., and US Endoscopy; S. Irani has received research support from Boston Scientific; R.J. Law has received consultancy fees from Boston Scientific, Olympus America, and ERBE, and research support from Cook Medical; D.E. Loren has received consultancy fees from Boston Scientific and Olympus America; D.L. Diehl has received consultancy fees from Boston Scientific, Cook Endoscopy, Olympus America, Pentax Medical, Lumendi, US Endoscopy, and C2 Therapeutics, and speaker’s fees from Boston Scientific and Olympus America; M.A. Al-Haddad has received consultancy fees and research support from Boston Scientific; D.K. Plescov has received consultancy fees from Boston Scientific, Olympus, Fuji, Nine Point Medical, and Medtronic; M. Huggett has received consultancy fees from Boston Scientific and Cook Endoscopy, and speaker’s fees from Boston Scientific, Cook Endoscopy, and Olympus; A.J. Trindade has received consultancy fees from Boston Scientific, Cook Endoscopy, and speaker’s fees from Apollo Endosurgery, Boston Scientific, Medtronic, Pentax Medical, and ReShape Lifescience, and research support from ERBE, C2 Therapeutics, and Ovesco; M.A. Khashab has received consultancy fees from and is on the advisory board of Boston Scientific and Olympus America, and has received consultancy fees from Medtronic. The remaining authors declare that they have no conflict of interest.

References

Bukhari M, Kowalski T, Nieto J et al. An international, multicenter, retrospective multicenter study of EDGE.


Chiang AL, Gaidhane M, Loren DE et al. 338 Impact of EUS-directed transgastric ERCP (EDGE procedure) access route on technical success and adverse events: a multi-center experience. Gastrointest Endosc 2018; 87: A870–A871


Califf RM, Mulhbaier LH. Health Insurance Portability and Accountability Act (HIPAA) must there be a trade-off between privacy and quality of health care, or can we advance both? Circulation 2003; 108: 915–918


Yang D, Draganov PV. ERCP in patients with Roux-en-Y gastric bypass: one size does not fit all. Gastrointest Endosc 2019; 89: 646


Park SW. Commentary on “Endoscopic ultrasound (EUS)-directed transgastric endoscopic retrograde cholangiopancreatography or EUS.”. Clin Endosc 2015; 50: 102


Irani S, Yang J, Khashab MA. Mitigating lumen-apposing metal stent dislodgment and allowing safe, single-stage EUS-directed transgastric ERCP. VideoGIE 2018; 3: 322